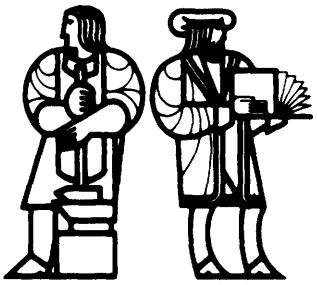

Reports to the President

1982-83

Massachusetts Institute of Technology

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President

For MIT, the year just ended was one of remarkable vitality and considerable tension. It was a year of sustained excellence in our academic programs, a year of budgetary stringency, a year of taking risks and launching bold, new ventures, a year of facing up to hard choices regarding the use of limited institutional resources. And it was, as always, a year in which insistence on the highest quality in all that we do remained a touchstone.

The extraordinary calibre of our programs was recognized by national surveys and reflected in our unprecedented level of private support. MIT's tradition of seizing, indeed, creating, major new opportunities was evident in the launching of Project Athena--a far-reaching, institutional experiment to incorporate computers in new ways into our teaching and learning. A word about these highlights is in order.

During the past year the survey of graduate programs and faculties sponsored by the Conference Board of the Associated Research Councils provided an independent measure of the quality which has been a signature of the Institute since William Barton Rogers shaped his dream of a new kind of educational institution. In these reports MIT led the nation in the number of programs ranked first.* This is gratifying, but not surprising, given the exceptional quality of our graduate programs, of the associated research programs, and of the faculty who are responsible for these activities. Indeed, this insistence on quality infuses all the programs of the Institute--at the undergraduate level as well, where educational programs draw from and contribute to the corresponding research activities and courses of graduate instruction.

The Institute's standing in the world of higher education is reflected, as well, in the support which we have been able to generate from individuals and institutions throughout the country and throughout the world. This past year witnessed the highest level of private support in the Institute's history: over $50 million. Contributions from individuals, both alumni and other friends of the Institute, accounted for the greatest portion of this increase. The increase of $9 million--or 22 percent--over the previous year is a tribute above all to our faculty, whose research and educational endeavors generate such confidence, enthusiasm, and high regard.

An example of the kind of vision and action so characteristic of our faculty and academic leaders is the inauguration this year of a massive educational experiment aimed at exploring how computers can accelerate and enhance the learning process. Started with resources provided by the Digital Equipment Corporation and IBM, the project is based on the premise that the next generation of personal computers represents a revolutionary new medium for learning.

This project, named Athena, after the Greek goddess of wisdom, calls for the integration of computers into educational programs throughout the university in ways that will help our students to learn more creatively and fully in a wide range of disciplines. Athena holds the promise of profoundly enhancing and extending the many ways in which we see and know the world around us.

Supporting the experiment will be thousands of personal computers and terminals, reinforced by mainframe computers, storage devices, and printers--all integrated into a

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*The study appraised programs in 32 fields, 17 of which exist at MIT. Thirteen of those programs were ranked in the top five and another three in the top ten. And nearly all of our other graduate programs, which were not included in this survey, are among the best in their fields.

single system. In addition, both IBM and DEC will have at least five representatives stationed at MIT to help develop the necessary computer networks for this project and to work with students and faculty in blending computers into the educational process. We are seeking additional, major private funds for support of Athena--funds which will be used to fuel the faculty effort required to put these resources to full use in our educational programs.

The ultimate aims of this joint venture are to find out exactly how these powerful tools can aid students in visualizing difficult concepts, breathe new life into laboratory experiments, help develop the skills, knowledge, and insights needed for design problems, and even help cultivate that elusive talent we call intuition. This work has the potential for helping universities educate students for many disciplines--engineering, science, architecture, humanities, social sciences, and management--people who are better prepared to meet the needs of business, industry, and our whole society.

* * *

These signs of MIT's vitality and stature spring from the remarkable relationship between the institution and the individuals who are MIT. In some ways, the Institute is simply an idea--one which has drawn together and sparked the imagination of countless faculty, students, and staff since its founding. The idea of MIT, which began with William Barton Rogers's original goals, has evolved in response to the changing patterns of knowledge and the changing needs of society, but there are constants in that idea which stand the test of time. Three years ago, at the start of my presidency, I discussed those qualities which we must preserve, even as we transform programs to meet the needs of the future: an unswerving commitment to the quality and vigor of our core activities in engineering and science ... the preservation and building of strong programs in the humanities, the arts, and the social sciences ... the education of our students for civilized leadership as professionals and as citizens of the world ... the intertwining of teaching and research as complementary and mutually reinforcing activities, a partnership that distinguishes MIT in the academic world. Looking to the years ahead, I spoke of the common goal which should inform all of our efforts: the development and sustenance at MIT of a more humane and complete intellectual mission, academic program, and sense of community.

We are now deeply involved in Institute-wide planning--a process which we see as a continuing feature of our academic programs and administrative services. I believe that conceptual, substantive, and integrative planning is the cornerstone of good leadership in higher education. While our current financial circumstances and the existence of deficits are a principal motivation for the investment of much energy and time in planning, these efforts have a purpose which transcends our present problems with the operating budget. Planning as an integral, ongoing part of our responsibilities is essential to preserving the vitality and excellence of the Institute in the future.

Planning is in no way intended to determine rigidly the future direction of the Institute and its programs. There will always be year-to-year modifications and room for unexpected exciting new initiatives. The history of MIT is powerful testimony that no planning process should, let alone could, stifle the originality and creativity of this community.

Rather, we see the planning process as a guide or framework in which we can develop ideas and make choices about our programs. And we must choose. We simply do not have the resources to do everything that we could do. We must, as part of our regular planning, assess the value and priority of existing programs as well as possible new initiatives.

To be effective, planning requires a shared sense of the Institute's fundamental purpose. Our mission can be stated simply: To provide the highest quality programs in education and research, with a strong commitment to public service and to diversity of backgrounds, interests, and points of view among the faculty, students, and staff.

When informed by the special qualities of this place, the mission becomes a set of expectations that defines MIT.

The single most important part of our mission and the strongest bond holding us together is the undergraduate program. The academic goals served by the undergraduate

program include, in variable measure, helping students to become qualified professionals; preparing them for entrance to graduate or professional school; and providing them with a broad cultural background in technology, the natural and social sciences, and the humanities. The degree of emphasis on each of these goals varies among different departments and from one student to another. We believe that this freedom and diversity are healthy and should be preserved, within the context of our goal that all MIT graduates achieve a serious understanding of science, on the one hand, and of the humanities and social sciences, on the other.

Although we value the historic emphasis of MIT on science and technology, we wish to encourage the diversity of academic opportunities and interests among our students and faculty. We believe that this makes for a significantly richer educational experience and more successfully attracts the best students, including, but by no means limited to, those whose main focus will be on science and technology. Indeed, significant contributions to science and technology will come more often from men and women who are broadly cultured than from those who are narrowly specialized.

Our goal of ensuring a diversity of interests and points of view in our community depends, as well, on the presence of men and women from different backgrounds and cultures at MIT. We have done very well in building an international community here, but we have not yet achieved this goal when it comes to minorities and women. This problem is especially acute in the case of the small number of blacks and other minorities on our faculty. We are committed to change that situation and will continue to make special efforts to help that happen.

At the graduate level, our future is determined largely by the research interests of our faculty, which provide the basis, both in terms of intellectual structure and experience, for graduate education. Indeed, the research interests of our faculty provide the grounding for almost all that we do here. These interests change with time, as the disciplines evolve and as different, societal needs emerge. These changes are not simply responses to outside circumstances, however. Our faculty are leaders, and their research and scholarship lead to many of the changing patterns of knowledge, new understanding, and emergent questions that define the research environment. It is clear that our research will stay at the cutting edge and that our graduate programs will do the same.

As an outstanding educational institution and as a great research center, MIT is a national and a world resource, one which should be contributing, by its research and teaching, to the solution of the overriding social problems of our time. These problems include the danger of war, particularly nuclear war; the protection of our environment; the depletion of resources, especially energy; the need to open the opportunities and benefits of this society to all of our citizens; and the need to improve productivity and alleviate poverty in our country as well as in the rest of the world.

These expectations of MIT constitute a very demanding mission. The success of this mission is forged by the people of MIT--the faculty, students, and staff who, through their commitment to excellence, make the difference, each day, each week, each year. MIT has an obligation to its members to provide the kind of living, learning, and working environment conducive to their best and most creative endeavors. As we plan for the future, we must pay special attention to those issues affecting the quality of life of the people responsible for the success of MIT.

In this report I will discuss several issues which bear directly on the quality of life at the Institute and which require continuing attention if we are to attract and sustain the calibre of faculty, students, and staff who have been responsible for the quality of MIT.

* * *

The faculty of MIT, indeed of any of the principal research universities, bear a resemblance to the Roman god, Janus, with his two faces, one looking inward to the house and the other gazing outward toward the world beyond. Members of the faculty are responsible, together and individually, for the educational programs of the Institute--those in departments, as well as the core subjects and requirements which constitute the basis of an MIT education for all undergraduate students. In these respects, the faculty establish the expectations and the standards as well as the intellectual content of our educational programs. At the same time, our faculty engage in and have an uncommon influence on developments in the world of ideas.

These dual, synergistic roles on the part of the faculty are a principal source of MIT's distinction and strength. While Janus brought two countenances to bear on his task, however, the MIT faculty member must make do with one. Most faculty would probably still agree that being a professor is the best job, but there are strains and pressures that are seriously eroding the quality of academic life and that may discourage the very best young people from selecting academic careers altogether.

One such strain grows out of the imperative of maintaining, year after year, a reasonably stable base of financial support for research efforts. This means that faculty members are responsible for raising not only a portion of their own academic-year salaries but also support for undergraduate and graduate students, postdoctoral students and fellows, research staff members and technicians as well. During the past year the average amount of research support raised by each faculty member in fields where external support is provided was about $300,000.

The task of raising such funds is formidable and demanding. It requires continuous attention to the development of new supportable ideas, sensitivity to the shifting interests of research sponsors and cultivation of those interests, and a great investment of time in the preparation of proposals, progress reports, and other communications which nurture the relationship between sponsor and principal investigator.

It is even more difficult when the federal government, the principal patron of basic research, falters with respect to the general level of such support, or shifts patterns of support abruptly and in ways which take no account of the time constants of universities, or adopts formalities which may serve bureaucratic ends but which needlessly complicate the task of the investigator.

Under these circumstances, it takes an extraordinary amount of time and energy for a faculty member to fund his or her research program. This is a source of unrelenting pressure, particularly for junior members of the faculty who must establish their reputation as independent researchers, and it intrudes seriously on time for reflection and contemplation, for discussion of ideas and problems with one's colleagues, and for exploration of uncharted territories. The pressures to raise money and develop a fundable research program are placing real constraints on the ideas and research directions a faculty member might pursue.

We need to support faculty members and their research in a way which enables and enhances their best efforts. This suggests renewed efforts to endow professorships and to increase our endowment in general, in order to bring into balance our faculty needs and our financial resources. Such an expansion would make it possible to relieve some of the pressure on faculty members to raise their own academic-year salary. It would also reduce the cost of research at MIT.

We should also continue to explore the opportunities for additional forms of research support, perhaps through closer cooperation with industry. At nearly $20 million, MIT already has one of the highest levels of industrially sponsored university research in the country, a record which speaks well of the enterprise of our faculty. There are questions as to whether the past strong growth in such support will continue, however, although certain fields (such as computation, biotechnology, materials, and microelectronics) seem promising. We should explore the opportunities here, paying special attention to the many questions which accompany industrial sponsorship of research--questions having to do with the character of research, the time scale on which it is done, the selection of research problems, and possible effects on the openness of the research enterprise.

And we must continue to work at containing the costs of research if we are to compete effectively for adequate support for our research programs. This means, in part, finding ways to reduce and stabilize the indirect cost and benefit burdens which add to the expense of research. This "overhead" is necessary to the performance of research, reflecting the real costs associated with space, libraries, departmental, interdepartmental and general administration, as well as the costs of the benefits which go with employment at MIT. For the past two years our budget reduction efforts have focused primarily on overhead costs and have been successful in reducing them by some 10 percent.

This has been a painful process, requiring the termination of programs and the elimination of jobs, and has contributed to tensions felt throughout the Institute this year. The reductions in support services which have been made or identified to date

amount to $9 million and will prevent the overhead rate from increasing by about four percentage points. The cost-cutting measures were also instrumental in reducing this year's anticipated deficit to $3 million, and in reversing the trend toward growing deficits in the future. This year an effort was made to identify all reductions to be taken in the administrative areas over the next two years, in order to lower anxiety over possible but unknown future cuts. We will continue to work with those administrative areas which have not yet met their goals for reducing expenses, and our planning efforts will continue to seek creative ways to provide support services without increasing the overhead on educational and research activities.

All too often, the demands of maintaining a research program come into conflict as well with the intellectual energy and time required for teaching, advising, and counseling students. These conflicts are particularly severe in several departments in the School of Engineering where undergraduate enrollments have burgeoned during the past decade. The number of students majoring in the Departments of Mechanical Engineering, Chemical Engineering, and Electrical Engineering and Computer Science is particularly high. The latter department has seen undergraduate enrollments double in fewer than 10 years, and that single department now enrolls one out of every three undergradates who have declared a major field of study. Counting both graduates and undergraduates, there are now more than 16 students per faculty member in that department (twice the Institute average), and each faculty member is supervising, on the average, eight thesis projects at any given time.

These enrollment patterns may or may not represent a sea change in student interests--many faculty believe they do--but at any rate, the teaching pressures on the Department of Electrical Engineering and Computer Science are already well beyond reason. We simply must find ways to limit this dramatic shift toward one department--not only to alleviate the strain on the faculty but also to ensure an essential diversity of intellectual interests and opportunities among our students.

Another factor affecting the quality of life for faculty at the Institute is the extraordinary competition for the recognition and stability which comes with promotion to tenure. There has always been a lively and stressful competition for tenured positions, even in the best of times. At the present time, however, with almost 70 percent of our faculty holding tenure, the competition for tenure and the associated pressures have been amplified. Not only are there budget constraints limiting the size of the faculty, but the age of the tenured faculty suggests that there will be only a modest number of retirements between now and the end of this decade.

These pressures, both real and magnified by the times and the grapevine, often cause an untenured faculty member to direct her or his energy almost entirely to research, where accomplishments can be assessed on the basis of "hard" data, and to assigned teaching. Often, little time or energy is left for the larger life of the institution, to say nothing of the family or the broader intellectual community.

We must find ways for the Institute to provide greater support for the junior members of our faculty. For example, we need to find ways to increase junior faculty salaries, and we should try to provide full salary support for an individual's initial appointment on the faculty. And we should seek additional funding for start-up research activities. We presently use both the Alfred P. Sloan Basic Research Fund and the Godfrey L. Cabot Solar Energy Fund in part for these purposes, when the nature of the work and the funds available permit. These endowed research funds are exceptionally valuable resources for MIT, and we should seek similar funding which could be employed to support research in other fields at the Institute.

It is important, too, that junior colleagues be given career guidance and advice by senior members of the faculty. Occasionally, the untenured faculty member feels isolated from senior colleagues, not having an established and effective relationship with a mentor. Such relationships are particularly important for women and for minority faculty who are often in the position of breaking new ground in their developing careers. It should go without saying, however, that all new members of this community need and can benefit greatly from relationships with senior colleagues who can provide the support, guidance, and constructive criticism necessary for professional development.

MIT has a record of producing great ideas and great people. If we are to be an institution for the future, we must preserve and enhance the quality of MIT as a congenial, stimulating, supportive setting for our faculty. For our junior faculty

colleagues in particular, we must take care that career pressures do not stifle them or drive them away.

This report deals largely with issues affecting the faculty, but the quality of this institution depends on the students and staff as well. We are a community--a community made up of energetic, intelligent, feisty, imaginative, and individualistic people, to be sure. But as I look at the faculty, undergraduates, graduate students, research staff, academic, administrative, and support staff, working together to create the best possible educational and research programs, I think we have a very special place here. We each bring distinctive talents to this place, and the quality of our living, learning, and working conditions profoundly affects the quality of our contributions.

* * *

For students at MIT, the quality of their education is influenced not only by the faculty and the curriculum but by the range of their own interests and backgrounds--by what they bring and by who they are. While students have been attracted to the Institute in large part for scientific and engineering studies, these young women and men have enriched MIT and each other by the diversity of their intellectual and social interests, racial and cultural heritages, learning styles, and economic backgrounds. As we order our priorities for the future, the preservation and enhancement of this diversity must remain high on the list.

A major influence on the matter of who chooses to attend MIT (and whether they do, and why) is the cost of education at the Institute. Our success in enrolling students with a variety of interests and backgrounds depends in large measure on the existence--and visibility--of adequate financial-aid programs for our students.

Currently, more than half of our undergraduates come from the top 25 percent of the national income distribution, while fewer than one-tenth come from the lowest quartile. Over half of all undergraduates here qualify for financial assistance from the Institute and receive help in the form of subsidized loans, term-time jobs, and grants or scholarships.

During the past year needy undergraduates each received an average of nearly $9,000 in financial assistance, about half of which was in the form of a scholarship or grant. The Institute's total budget for grants to undergraduates last year was more than $12 million, $8 million of which came from MIT sources. Given the increasing need for financial aid, the Institute's scholarship endowment is no longer sufficient to meet those needs, and last year alone we spent $4 million in unrestricted funds to cover that need. The Institute's finances are stretched by these commitments to meet our financial aid policy. We have a pressing need to increase dramatically our endowment for financial aid: even a doubling of this endowment would not completely resolve this problem.

The Institute is not the only one to be stretched, however. Grants are awarded only after students and their parents contribute their "fair share." The average parental contribution last year was nearly $4,000; needy students contributed some $1,400 in summer earnings and assets; and met a "self-help" obligation of $4,000 through a combination of term-time work and loans.

Now I am talking about averages here; some families incur higher financial obligatins, some lower. But it is clear that the costs--in terms of finances, time, and energy--are high, and we are concerned increasingly that these financial pressures influence students' choice of fields, academic performance, and opportunities to do anything besides work and study. That is a concern for the students who <u>are</u> here. Beyond that, we are asking ourselves whether the costs of attending MIT <u>are</u> so high, or are <u>seen</u> as so high, that they discourage other students from even applying.

At the graduate level we have similar concerns. While many graduate students in science and engineering are supported as research or teaching assistants, many in architecture, planning, the social sciences, and management are dependent solely upon personal resources, very scarce term-time jobs, and the Guaranteed Student Loan Program. As with the undergraduates, I am concerned about the effects of these financial circumstances on students' decisions whether or not to attend MIT and on the educational well-being of those who come: students who are preoccupied with financial issues are simply not able to bring their full energies to bear on their academic programs.

As these observations suggest, the cost of an MIT education and our financial aid resources are problematic for the university and the student alike. Last fall I appointed a task force to review our present financial-aid policy--beginning with undergraduate financial aid. That task force, chaired by Associate Provost Frank Perkins, was charged with evaluating the consequences and the costs of our present policy, to develop alternatives for consideration, and to make recommendations on future policy. We expect a report from that task force during the fall term.

The concerns for ensuring continued access to MIT by students from varied economic circumstances is but one issue relating to our goal of educating students with a broad range of perspectives, interests, and backgrounds. Beyond access, financial considerations seem to influence students' choice of fields and future career once they are here and, I fear, seem to reinforce a trend toward professionalism in undergraduate education.

I referred earlier to the problems created for the faculty by the dramatic increase in engineering enrollments--particularly in Electrical Engineering and Computer Science. This increase, certainly in part evidence of students' greater concern with the economic consequences of their academic decisions, also affects the quality of undergraduate education at MIT. The concern for getting on with one's professional education is reflected not only in choice of field but in a growing tendency to specialize as early as possible. Such decisions frequently limit the opportunities for a more general, exploratory, and varied educational experience which is especially important at the undergraduate level.

Our undergraduates should be encouraged--and should have the opportunity--to experience a variety of ways of seeing and knowing, of thinking about and grappling with the important questions of our time. It is true that scientific education and progress demand specialization, but we must guard against the companion pressures toward isolation and narrowed vision. We have a responsibility to elucidate not only the powers but the limitations inherent in different disciplines and to explore the ways in which they inform each other.

The success of such goals depends on our being able to attract students with serious intellectual interests in a variety of fields and on our striking an appropriate balance between general and preprofessional educational goals.

We must, I believe, step up our efforts to present MIT as the university that it is in order to draw students whose serious engagement in a broader spectrum of fields helps to create a richer and more varied academic culture. Another way to do this might be to embark on a more ambitious program of transfer student admissions, with that specific goal in mind. Given the extraordinary enrollments in Electrical Engineering and Computer Science, we must find ways to generate student interest in other fields. I hope we can do so in a way which maintains our tradition of admitting students to the Institute rather than to specific schools or departments, but it may not be possible to preserve this freedom if enrollment pressures in engineering do not abate.

While the faculty share certain ideas about the foundation of an MIT education, the questions about balance between general and specialized education are by no means settled. Are the General Institute Requirements, which form the introduction to an MIT education for all undergraduates and which were last revised nearly 20 years ago, appropriate to the 1980s? Do departmental programs reflect a reasonable balance between general and preprofessional educational goals?

These are fundamental questions having to do with how students can best benefit from--and contribute to--the quality of MIT and the education we offer. The Committee on Educational Policy has been working steadily on the improvement of undergraduate education here. In remarks to the Corporation last spring, the outgoing Chairman of the Faculty, Professor Felix Villars, noted that while the faculty as a whole has not called for a reexamination of our educational premises and practices, he has heard a great deal of individual comment about these questions. He suggested that the time has come for a broad discussion among the faculty on issues of educational policy--a discussion which would generate a wide range of views and ideas which could lead to a shared understanding and set of recommendations concerning our educational goals. I welcome such an initiative and am pleased that Professor Villars's successor as Faculty Chairman, Professor Arthur Smith, is enthusiastic about engaging the faculty in consideration of these and other issues basic to the mission of MIT.

* * *

As we consider our future, I am reminded over and over that our teaching, research, and learning are not only enhanced but often made possible by all those who work to support our academic program. As I noted earlier, our planning and embarking on new ventures this year was accompanied by stringent cost-cutting measures, particularly on the administrative side of the house.

Planning for the development of the Institute, especially when undertaken in a climate of financial stringency, creates uncertainty and significant strain for all who work here. These uncertainties and strains are particularly acute for members of the administrative and support staff, who have borne most of the consequences, direct and indirect, of the staff reductions which have come about.

At the same time, the staff have shown an extraordinary willingness to lend their insights and experience to the planning activities--and to shoulder the consequences of organizational consolidation and change.

Throughout the Institute, staff members have stretched to provide high-quality service with lower budgets and reduced support, coming up with creative suggestions and cost-saving ideas. While the cost of the overhead--the administrative services in support of the academic program--has been the target for most reduction, the people in the administrative areas have become part of the solution rather than the problem. With a characteristic sense of dedication, often a sense of humor, and a "can-do" attitude, the staff has carried on under far-from-usual circumstances--and has gone the extra mile, time and again.

This is not to say that there have been no effects on the morale of the staff. The very closeness and collegiality in the MIT community--which are the sources of such goodwill in hard times--make staff reductions all the more visible and painful. And those who may be confident about their future employment may still wonder whether there will be opportunities for increased job satisfaction and professional development.

In any time--but particularly in these times--we must pay attention to the quality of MIT as a place to work. This means bringing staff into decisions affecting their jobs. It means greater willingness among departments to cooperate on Institute-wide projects--not only as a way of meeting new challenges with fewer resources but as a way of expanding professional experience and opportunity. And it calls for particular recognition on the part of senior officers and others of jobs well done.

I believe we have the spirit and the will to keep MIT an exciting and rewarding place to work. I know of no other university which enjoys such strong support and participation in its mission by all who work here. We must do all we can to keep that good fortune with us.

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This place demands much. Some say too much. The demands on students, faculty, and staff <u>are</u> extraordinary--and so are their achievements. We must take care that pride in our success is not joined to pride in our ability to survive this place, however. As we plan for our future, we must remember that the quality of this university derives from the quality of the individuals here. The ways in which we support them, the kind of environment we provide for those who study and work here are fundamental to the attainment of the best and most creative endeavors. The creation of a more complete intellectual mission, educational program, and sense of community: the idea of MIT and the success of MIT demand no less.

Paul E. Gray
September 1983

In Special Recognition

Every year there are occasions which remind us of the unique manner in which individuals help to mold the character of the Institute. This past year several key leadership roles at the Institute changed, and those transitions were occasion for special recognition. In 1982 Howard W. Johnson announced his intention to retire from the Chairmanship of the Corporation at the end of the 1982-83 academic year. During his 28 years of service to the Institute, Howard Johnson has been a staunch defender of the university, a champion of the rights of all who study and work here, and a statesman and spokesman for higher education.

As President and as Chairman of the Corporation, Howard Johnson is living testimony to his own proposal that institutions, like individuals, need care if we are to have a society worth living in. His vitality and disciplined energy, his wise judgment, his warm relations with his colleagues, his humility, and his remarkable sense of humor have enriched all. I am delighted that he will continue as Life Member of the Corporation, Honorary Chairman, and as Special Faculty Professor.

At its December meeting the Corporation unanimously elected David S. Saxon as Chairman of the Corporation, effective July 1, 1983. Dr. Saxon received his bachelor's degree from MIT in 1941 and in 1944 his Ph.D. degree in physics also from MIT. In 1947 Dr. Saxon went to the University of California, where he served in a variety of positions for 36 years, serving as President and Chief Executive Officer from 1975 until June 1983.

Dr. Saxon comes to MIT with a lifetime of experiences at another great university. The perspectives which he brings from the University of California will be of enormous value to MIT and I am elated that he has agreed to join his alma mater, taking on the leadership of the MIT trustees and bringing his energies to bear on fundraising for our academic programs.

In the spring Kenneth R. Wadleigh, Vice President and Dean of the Graduate School, announced his decision to return to the Mechanical Engineering faculty following a year's leave of absence. Professor Wadleigh had a major role in the building of many vital MIT programs including the residence system for undergraduates; the organization and growth of student services throughout the 1960s; the development of graduate school policies, recruitment of minorities, and support for all graduate students, and the establishment of high quality health services for the entire MIT community. Ken Wadleigh's limitless energy and dedication to MIT, his extraordinary contributions, and his no-nonsense, efficient style have won him a special place in the history of this institution.

The special character of MIT is also seen each year in the achievements and honors of its faculty. While it is not possible to take note of every such distinction, there are some highlights which deserve mention.

In the spring, five MIT faculty members were elected to membership in the National Academy of Engineering. The faculty members are: Thomas B. Drew, Professor Emeritus in the Department of Chemical Engineering; Harry C. Gatos, who holds a joint appointment as Professor in the Department of Materials Science and Engineering and the Department of Electrical Engineering and Computer Science; Charles C. Ladd, Professor in the Department of Civil Engineering; Alan L. McWhorter, Professor in the Department of Electrical Engineering and Computer Science and also Head of the Solid State Division at Lincoln Laboratory; and Kenneth A. Smith, Associate Provost and Vice President for Research and Professor in the Department of Chemical Engineering. This election brings to 71 the number of MIT faculty who are members of the Academy.

Professor George B. Benedek of the Department of Physics was elected a member of the national Institute of Medicine.

This past year the National Academy of Sciences elected four of MIT's faculty as members of the Academy. They are: Alar Toomre, Professor of Mathematics; Mary Lou Pardue, Professor of Biology; Phillip A. Sharp, Professor of Biology, and Stanley R. Hart, Professor of Geology and Geochemistry.

Later in the spring the American Academy of Arts and Sciences elected the following six faculty members: Victor W. Guillemin, Professor in the Department of

Mathematics; Harold M. Stark, Professor in the Department of Mathematics; Robert W. Balluffi, Professor in the Department of Materials Science and Engineering; Erich P. Ippen, Professor in the Department of Electrical Engineering and Computer Science; Jack L. Kerrebrock, Professor in the Department of Aeronautics and Astronautics, and Phillip A. Sharp, Professor in the Department of Biology.

Four members of the MIT community were elected fellows of the American Association for the Advancement of Science: Loren R. Graham, Professor in the Program in Science, Technology, and Society; Edward N. Lorenz, Professor in the Department of Earth, Atmospheric, and Planetary Sciences; Kosta M. Tsipis, Principal Research Scientist in the Department of Physics, and Sheila E. Widnall, Professor in the Department of Aeronautics and Astronautics.

Earlier in the year Norman C. Rasmussen, Professor in Nuclear Engineering, was nominated by President Reagan to serve a six-year term on the National Science Board. The National Science Board is the policymaking body for the National Science Foundation and includes 24 members selected by the President and the Director of the Foundation.

Last fall Institute Professor Walter A. Rosenblith was honored by Israel's Weiszmann Institute of Science when he received the first Dewey D. Stone-Harry Levine Arts and Sciences Award. Professor Rosenblith has been a governor of the Weiszmann Institute since 1973 and earlier was Weiszmann Lecturer there.

In the late spring Jerome B. Wiesner, Institute Professor and President Emeritus, was awarded the First Class of the Order of the Sacred Treasure by the Government of Japan. He was selected to receive this award for his support of the growth of numerous MIT programs strengthening ties with Japan and contributing to the exchange of science and technology between the United States and Japan.

Professor Charles F. Sabel in the Program in Science, Technology, and Society was the recipient of a MacArthur Prize Fellows award given by the John D. and Catherine MacArthur Foundation. The prize was established to recognize and give exceptionally talented individuals the financial freedom to pursue their field of interest.

Within the Institute, Herman Feshbach, Cecil and Ida Green Professor of Physics, was appointed Institute Professor upon recommendation of a special faculty committee. This honor is bestowed on a faculty colleague who has achieved special distinction through a combination of leadership, achievement, and service in the scholarly, educational, and general intellectual life of the Institute or wider academic community.

Robert W. Mann was selected by colleagues to be the 1983-84 recipient of the James R. Killian, Jr., Faculty Achievement Award. The Award recognizes extraordinary professional accomplishments and service to the Institute. The Award citation reads, in part, "It is a subtle synthesis that leads to real, working, and needed engineering devices, a synthesis that is based on analysis and understanding, but that goes beyond to judgment, to a sense of values, and to sustained leadership. Those are what Robert Mann has brought to his work at MIT, work known worldwide for two decades, and recognized by consultancies, editorships, chairmanships, and awards too numerous to list."

In late May, Associate Professors Isabelle de Courtivron, a scholar in French language and literature, and Warren P. Seering, a mechanical engineer specializing in machine design and robotics, were corecipients of the first Harold E. Edgerton Faculty Achievement Award. The Award recognizes young faculty members for outstanding achievements in research, scholarship, and teaching.

Several changes in senior posts in the academic administration were announced this past year. New department heads announced during the year include Jerome I. Friedman, Department of Physics; Jack Kerrebrock, Department of Aeronautics and Astronautics; David N. Wormley, Department of Mechanical Engineering, and Fernando J. Corbato, Acting Associate Head of the Department of Electrical Engineering and Computer Science.

On July 1, 1983, the Department of Earth and Planetary Sciences and the Department of Meteorology and Physical Oceanography merged and became the Department of Earth, Atmospheric, and Planetary Sciences. William F. Brace has remained as Head

of the new department and Peter H. Stone became Director of the newly created Center for Meteorology and Physical Oceanography.

Other changes in the academic administration announced during the year included the appointment of Nicholas A. Ashford, Director of the Center for Policy Alternatives; Emilio D. Bizzi as Director of Whitaker College of Health Sciences, Technology, and Management, succeeding Irving M. London who will continue to serve as Director of the Harvard-MIT Divison of Health Sciences and Technology; H. Kent Bowen, Director of the Center for Materials Processing; Jeffrey Goldstone, Director of the Center for Theoretical Physics; Arthur K. Kerman, Director of the Laboratory for Nuclear Science; Thomas H. Lee, Director of the Electric Power Systems Engineering Laboratory; David Litster, Director of the Center for Materials Science and Engineering; Pauline Maier, History Section Head, Department of Humanities; James R. Melcher, Associate Director of the Electric Power Systems Engineering Laboratory; Ernest J. Moniz, Director of the MIT Bates Linear Accelerator; James Paradis, Head, Writing Program, Department of Humanities; Joseph Salah, Director of the Haystack Observatory; Marcus A. Thompson, Music Section Head, Department of Humanities.

Several changes in the Institute's central administration also were announced during the year. The administrative responsibilities which Professor Wadleigh carried as Vice President and Dean of the Graduate School have now been assigned to several officers of the Institute: Frank E. Perkins will assume responsibilities as Dean of the Graduate School in addition to continuing as Associate Provost; the Medical Department will report to Vice President Constantine B. Simonides; the Division of Comparative Medicine will report to Associate Provost and Vice President for Research, Kenneth A. Smith, and the Registrar will report to Jack H. Frailey, Director of Student Financial Services. Other changes in the administration include the appointment of John B. Turner as Assistant Provost (in addition to continuing as Associate Dean of the Graduate School); James D. Bruce, Director of Information Systems; Eric Johnson, Assistant Dean for Resource Development in the School of Engineering; Frederick J. McGarry, Director of Summer Session; Donna R. Savicki, Assistant Dean for Administration in the School of Engineering; and James D. Utterback, Director of the Industrial Liaison Program.

The Institute was saddened this year by the deaths of several longtime friends and colleagues. We miss their presence among us and are grateful for their contributions to this community.

John Chipman, professor emeritus of metallurgy, died on May 14, 1983 at the age of 86. He joined the faculty at MIT in 1937 as a professor of metallurgy, was appointed Head of the Department of Metallurgy in 1946 and remained as Head until he retired in 1962. He was recognized internationally for his important contributions to the development of atomic power during World War II and for his applications of the theories of physical chemistry to steel-making.

Paul V. Cusick, a longtime member of the MIT administration (1944-1978), died at the age of 65 on December 15, 1982. During his career at MIT, he became a national leader among research university business officers and an authority on university-government relations. He served in a variety of financial administrative positions at the Institute, his last being Vice President for Fiscal Relations which he held from 1973 until his retirement.

Lawrence J. Heidt, associate professor of physical chemistry emeritus, died on April 4, 1983, at the age of 78. After finishing his doctoral work at Harvard in 1935, he joined the MIT faculty, teaching courses in general and physical chemistry until his retirement.

George J. Leness, a 1926 graduate of MIT, a national leader in the investment banking industry, and a former track star at the Institute, died on August 17, 1983, at the age of 80. A retired Chairman and Chief Executive Officer of Merrill Lynch, Pierce, Fenner and Smith, he played a major role in shaping the investment policies of MIT through his long service on the Investment Committee. He served as a member of the Corporation from 1949 to 1954, and became a Life Member in 1961.

David A. Shepard, a 1926 graduate of MIT, an internationally respected business statesman, and a loyal alumnus, died July 10, 1983, at the age of 80. A retired executive vice president of the Exxon Corporation, Mr. Shepard was a member of the MIT Corporation for 32 years, beginning as an Alumni Term member in 1951, becoming a

Life Member in 1955 and Life Member Emeritus in 1977. He served on the Corporation's Executive Committee, and in doing so had the distinction of serving with four MIT presidents.

Alexander Smakula, professor of crystal physics emeritus in the Department of Electrical Engineering and Computer Science, died May 17, 1983, at the age of 82. Dr. Smakula came to MIT in 1951 as associate director of the Laboratory for Insulation Research under Dr. Arthur R. Von Hippel and subsequently founded and headed the Crystal Physics Laboratory. He was recognized internationally for conceiving the idea and the technology for permanent nonreflective coatings now used on almost all optical surfaces.

W. Van Alan Clark, Jr., member of the MIT Corporation since 1972, graduate and onetime faculty member of MIT, died July 16, 1983, at the age of 63. Retired president and chairman of the Sippican Corporation, Mr. Clark was an active philanthropist contributing not only personally to the support of MIT but also assisting greatly in securing corporate and foundation support.

Mrs. Helen F. Whitaker, an advocate of basic research and advanced education in the field of human health, died September 14, 1982, at the age of 76. A Life Member of the MIT Corporation, she was an early advocate of research and education in the life sciences. Along with her husband, she was a major benefactor of MIT, playing a major role in the expansion here of basic research in the health and life sciences and in the health professions.

Professor Emeritus Carroll L. Wilson, a member of the MIT faculty since 1959, died January 12, 1983, at the age of 72. A 1932 alumnus of MIT, Professor Wilson served as assistant to President Karl T. Compton until 1936. He was the first manager of the Atomic Energy Commission in the late 1940s and, as professor of management in the early 1960s, he founded and directed the MIT Fellows in Africa and Latin America programs. Renowned as a leader in the field of ecology and world energy supplies, he spent much of his career seeking solutions to problems with global dimensions.

Lester Wolfe, a member of the MIT Class of 1919 who went on to become an inventor, builder, innovative business leader, and patron of both the arts and scientific research, died July 6, 1983, at the age of 86. A benefactor of various scientific endeavors at MIT, Mr. Wolfe has supported research ranging from molecular biology to spectroscopy to archaeology. He also established the Kathlyn Langford Wolfe prizes for undergraduate and graduate students in materials science, the humanities, and the arts.

Statistics for the Year

The following paragraphs report briefly on various aspects of the Institute's activities and operations during 1982-83.

Registration

In 1982-83 student enrollment was 9,475, compared with 9,510 in 1981-82. This total comprised 4,619 undergraduates (compared with 4,562 the previous year) and 4,856 graduate students (compared with 4,940 the previous year). Graduate students who entered MIT last year held degrees from 394 colleges and universities--231 American and 163 foreign. The international student population was 1,987, representing 11 percent of the undergraduate and 30 percent of the graduate population. These students were citizens of 96 countries.

Degrees awarded by the Institute in 1982-83 included 1,135 bachelor's degrees, 1,125 master's degrees, 67 engineer's degrees, 432 doctoral degrees--a total of 2,759.

In 1982-83 there were 1,977 women students (1,048 undergraduate and 929 graduate) at the Institute, compared with 1,879 (977 undergraduate and 902 graduate) in 1981-82. In September 1982, 266 first-year women entered MIT, representing 24 percent of the entering class.

In 1982-83 there were 968 minority students* (817 undergraduate and 151 graduate) at the Institute, compared with 929 (725 undergraduate and 204 graduate) in 1981-82. The first-year class entering in September 1982 included 265 minority students, representing 24 percent of the class.

Student Financial Aid

During the academic year 1982-83 the student financial aid program was again characterized by increases in the overall need for financial aid and in the aggregrate amount of grants made available. There was an increase in the amount of MIT loans awarded. Federally guaranteed loans obtained from commercial sources showed a significant decrease.

A total of 2,532 undergraduates who demonstrated the need for assistance (55 percent of the enrollment) received $12,319,800 in grant aid and $2,444,083 in loans. The total, $14,763,883, represents a 17-percent increase in aid compared with last year.

Grant assistance was provided by the scholarship endowment in the amount of $3,537,795; by outside gifts and Federal allocations to MIT for scholarships in the amount of $1,549,976; and by direct grants to needy students totaling $3,052,013 (a 13 percent increase over last year). Scholarship assistance from MIT's own operating funds was provided to the extent of $4,007,557 (a 52-percent increase over last year's level and the largest allocation ever). The special program of scholarship aid to minority group students represented an additional $172,459 from specially designated funds. An additional 514 students received grants from outside agencies, irrespective of need. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of about $3,291,904 and which raised the principal of the endowment to $33,804,455.

Loans totaling $2,444,083 were made to needy undergraduates--a 21-percent increase over last year. Of this amount $509,349 came from the Technology Loan Fund and $1,934,734 from the National Direct Loan Fund. Not included in the foregoing summary is an additional $6,029,753 obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources. This represents an 18-percent decrease in the use of these programs over last year, reflecting a moderate tightening of eligibility requirements.

Graduate students obtained $1,015,635 from the Technology Loan Fund, about half of which was loaned to international students and did not qualify for the Federal interest subsidies and guarantees available under the Guaranteed Student Loan Program. In addition, $322,580 was loaned by MIT under the Guaranteed Student Loan Program. The total, $1,338,215, represents a 35 percent increase over last year's level. Graduate students obtained $3,441,670 from outside sources under the Guaranteed Student Loan Program--15 percent below last year's level. The total loaned by MIT to both graduate and undergraduate students was $3,782,298, a 25-percent increase over last year's level.

Career Services and Preprofessional Advising

For students in many disciplines, 1982-83 was a difficult year to look for a job. Employers sent out few recruiters and were slow in making offers. Because of the softness in the price of oil and the presence of excess capacity in many sectors of the chemical industry, chemical engineers--normally in demand--felt the pinch particularly. Not all students have reported their postgraduation plans, but it is clear that a number of chemical engineers had not found jobs in June. Firms reporting on their offers to students reported only one-fourth as many offers to chemical engineers as in 1981-82. The impact of the recession in other fields, while real, was less spectacular.

Demand was strongest in electrical engineering and computer science. The demand came from every sort of employer, from electronics firms to investment banks, from government laboratories to entrepreneurs hiring their first employees. If some firms were not hiring--many had hiring freezes--there were many others which were.

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*Minority students include 314 Blacks (non-Hispanics), 18 native Americans, 182 Hispanics, and 454 Asian Americans.

Altogether, 405 employers made recruiting visits, compared with 450 in 1981-82. A total of 1,401 students had 9,675 interviews. Anxiety about the job market prompted students to have more interviews. The average number of interviews per student was 6.9, compared with 6.4 in 1981-82, 5.8 in 1980-81, and 4.9 in 1979-80.

There was a decline in the number of applicants to medical school. A total of 101 candidates filed applications, down from 130 in 1981-82. They included 69 seniors, 13 graduate students, and 19 alumni. Preliminary returns indicate that 78 were accepted. Information is not available yet on the number of students proceeding to graduate study in other fields.

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, amounted to $588,702,000, an increase of 14 percent over 1981-82. Education and general expenses--excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory--amounted to $255,541,000 during 1982-83, compared with $227,165,000 in 1981-82. The direct expenses of campus departmental and interdepartmental sponsored research increased from $143,537,000 to $149,478,000; the direct expenses of the Lincoln Laboratory's sponsored research increased from $144,726,000 to $183,683,000, largely because of increased subcontracts and equipment purchases.

For the second time in recent years the financial operations of the Institute were not in balance, with expenses exceeding income by approximately $3 million. Current revenues used to meet the Institute's operating expenses totaled $578,382,000, augmented by $7,214,000 in unrestricted funds. The remaining $3,106,000 needed to meet expenses was met from a special distribution to funds from the reserve of investment income held for future distribution.

The construction program of the Institute continued to make progress in 1982-83, with book value of educational plant facilities increasing from $278,949,000 to $288,392,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of $514,808,000 and a market value of $767,228,000. This compares to book and market values of $463,786,000 and $539,736,000 last year.

Gifts

Gifts, grants, and bequests to MIT from private donors increased by 22 percent in 1982-83 to a total of $50,025,000, as compared with $41,055,000 in 1981-82. This is the largest amount of gifts received in a single year in the history of the Institute. The Alumni Fund reported gifts of $8,662,000 for the year, a new record.

Physical Plant and Campus Environment

MIT's first residence for single graduate women opened in February with the completion of renovations to the building which formerly housed the medical infirmary. It provides accommodations for 45 women in a variety of singles and doubles with lounge and kitchen-dining facilities on each floor. This residence, Green Hall, was dedicated on June 10, 1983, in honor of Ida Flansburgh Green of Dallas, Texas, who has long been a friend and benefactor to women pursuing graduate studies at the Institute.

Other projects completed during the year included the Edward Pennell Brooks Center, a residence and conference facility in Dedham, adjacent to Endicott House; renovation of the lower floors of the Sloan Building on Memorial Drive and the Plasma Fusion Center and Tandem Mirror Facility in the former Nabisco Building on Albany Street.

Projects under construction are the EG&G (Edgerton, Germeshausen, and Grier) Education Center, adjacent to the Fairchild Electrical Engineering Building, to be completed in the fall; the Arts and Media Technology Building on Ames Street, scheduled for completion in the spring of 1984; and the complete rehabilitation of the undergraduate chemistry laboratories on the top floor of Building 4, scheduled to be completed for the 1983 fall term.

The first phase of the Microsystems Technology Laboratories project, which involved vacating Building 39 to make way for construction of the new facility, was successfully completed in May 1983. The Information Processing Services computers were moved to renovated space in the former Supersonic Laboratory on the West Campus. Computer user services and administration were moved to renovated space in the former medical department area in Building 11 and Building 4, while the Industrial Liaison Program was consolidated on two floors of the Suffolk Building on Main Street. All these moves were made without extensive interruption of computer services.

Projects in the design phase and scheduled for a construction start during the summer of 1983 are the Microsystems Technology Laboratories facility in the vacated Information Processing Services building; renovation of the upper floors of the Sloan Building; major renovation of 175 Albany Street to accommodate the Nuclear Magnetic Resonance (NMR) facility and Plasma Fusion Center activities; and the renovation of the remaining space in Building 11 to house the Joint Computer Facility and Project Athena on the first floor and the Graphic Arts Copy Center in the basement.

The program to install smoke detectors in all dormitory rooms and apartments is near completion. This effort, conducted by the Safety Office and the Housing Office, was required to meet new city and state fire safety codes.

Implementation of the East Campus-Senior House residents' proposal to install kitchen/dining facilities within their houses is well under way, with completion expected by the end of the summer. With these new community kitchens--17 in total--the residents will no longer be required to participate in the commons program.

The dining program completed its last year of transition. Next year all four classes in those houses with dining halls will participate in the commons program. Changes continue to be implemented, wherever possible, in an attempt to meet the ever-changing needs of students. The contributions of the House Commons Committees, Dining Advisory Board, students, and employees have been most significant.

A new food service facility was opened in February on the first floor of the Sloan Building. This unit, operated as an adjunct to the Faculty Club, serves light lunches, snacks, and beverages Monday through Friday. It has been well received by the community and averages approximately 700 customers each day.

Personnel Changes

CORPORATION

DEATHS

Helen F. Whitaker
Life Member, Emerita

CHANGES OF APPOINTMENT

Howard W. Johnson
Life Member
Honorary Chairman of the Corporation

Ellmore C. Patterson
Life Member

David S. Saxon
Chairman of the Corporation

Edward O. Vetter
Life Member

Kenneth J. Germeshausen
Life Member, Emeritus

Gregory Smith
Life Member, Emeritus

Joseph J. Snyder
Life Member, Emeritus

John J. Wilson
Life Member, Emeritus

ELECTIONS

Robert A. Charpie
Member

Herbert H. Dow
Member

Joseph G. Gavin, Jr.
Member

W. H. Krome George
Member

Glen Head
Member

Floyd A. Lyon
Member

Denman K. McNear
Member

Rhonda E. Peck
Member

Mary Frances Wagley
Member

MEMBER EX-OFFICIO

Michael S. Dukakis
Governor
Commonwealth of Massachusetts

GUEST OF THE CORPORATION

Professor Robert W. Mann
President
Alumni Association

TERMS EXPIRED

Paul Hotte
Member

Brian G. R. Hughes
Member

I. M. Pei
Member

Stanley M. Proctor
Member

Emily L. Wick
Member

FACULTY

RETIREMENTS

James M. Austin
Office of Summer Session

Edward A. Crocker
Athletic Department

Morton Finston
Department of Aeronautics and Astronautics

Robert L. Kyhl
Department of Electrical Engineering and Computer Science

James F. Thomson
Department of Linguistics and Philosophy

H. Philip Whitaker
Department of Aeronautics and Astronautics

RESIGNATIONS

Professors

Edward H. Bowman
Sloan School of Management

Joan Bresnan
Department of Linguistics and Philosophy

C. Allin Cornell
Department of Civil Engineering

John V. Evans
Department of Meteorology and Physical Oceanography

Louis N. Howard
Department of Mathematics

Lawrence H. Summers
Department of Economics

Associate Professors

Edward B. Allen
Department of Architecture

Richard P. Bagozzi
Sloan School of Management

Michael Bishop
Department of Architecture

Joao G. de Oliveira
Department of Ocean Engineering

Michael Fardis
Department of Civil Engineering

John D. Fernstrom
Department of Nutrition and Food Science

Christos Georgakis
Department of Chemical Engineering

Peter Huber
Department of Mechanical Engineering

Gary L. Kavanagh
Department of Ocean Engineering

Shimon Levit
Department of Physics

Starr Ockenga
Department of Architecture

J. Herbert Hollomon
School of Engineering

Thomas Postlewait
Writing Program
Department of Humanities

Michael M. Salour
Department of Electrical Engineering and Computer Science

Costas G. Vayenas
Department of Chemical Engineering

Wilma E. Wetterstrom
Anthropology/Archaeology Section
Department of Humanities

Martin B. Zimmerman
Sloan School of Management

Assistant Professors

Alan Bleier
Department of Materials Science and Engineering

Alan D. Brinkley
History Section
Department of Humanities

Peter Brownell
Sloan School of Management

Dorothy Leonard-Barton
Sloan School of Management

Philip Marcus
Department of Mathematics

M. Lynne Markus
Sloan School of Management

Edwin W. McCann
Department of Linguistics and Philosophy

Manoj K. Prasad
Department of Mathematics

Jane Roessner
Literature Section
Department of Humanities

Raaj Sah
Department of Urban Studies and Planning

S. Shankara Sastry
Department of Electrical Engineering and Computer Science

Selim M. Senkan
Department of Chemical Engineering

Marilyn J. Simon
Department of Economics

PROMOTIONS

To Professor

John W. Belcher
Department of Physics

Dimitri P. Bertsekas
Department of Electrical Engineering and Computer Science

Min Chen
Department of Physics

Chryssostomos Chryssostomidis
Department of Ocean Engineering

Robert F. Cohen
Department of Chemical Engineering

Charles L. Cooney
Department of Nutrition and Food Science

Charles C. Counselman, III
Department of Earth and Planetary Sciences

Herbert H. Einstein
Department of Civil Engineering

Robert W. Field
Department of Chemistry

Clifton G. Fonstad, Jr.
Department of Electrical Engineering and Computer Science

Walter M. Hollister
Department of Aeronautics and Astronautics

Nancy H. Hopkins
Department of Biology

June Matthews
Department of Physics

Mary C. Potter
Department of Psychology

Ronald G. Prinn
Department of Meteorology and Physical Oceanography

Lawrence H. Summers
Department of Economics

Toyoichi Tanaka
Department of Physics

Irene Tayler
Literature Section
Department of Humanities

Robert A. Weinberg
Department of Biology

Nigel H. M. Wilson
Department of Civil Engineering

Patrick H. Winston
Department of Electrical Engineering and Computer Science

To Associate Professor

Arvind
Department of Electrical Engineering and Computer Science

Lawrence S. Bacow
Department of Urban Studies and Planning

Ahmet N. Berker
Department of Physics

Edward A. Boyle
Department of Earth and Planetary Sciences

Robert A. Brown
Department of Chemical Engineering

Michael N. Fardis
Department of Civil Engineering

Stan N. Finkelstein
Sloan School of Management

Elizabeth Garrels
Foreign Languages and Literature Section
Department of Humanities

Harold F. Hemond
Department of Civil Engineering

Pierre A. Humblet
Department of Electrical Engineering and Computer Science

Richard K. Lester
Department of Nuclear Engineering

Shimon Levit
Department of Physics

Jae S. Lim
Department of Electrical Engineering and Computer Science

Michael D. Meyer
Department of Civil Engineering

David F. Noble
Program in Science, Technology, and Society

Thomas E. Postlewait
Writing Program
Department of Humanities

Robert P. Redwine
Department of Physics

Charles F. Sabel
Program in Science, Technology, and Society

Donald R. Sadoway
Department of Materials Science and Engineering

Robert T. Sauer
Department of Biology

William C. Unkel
Department of Mechanical Engineering

Wilma C. Wetterstrom
Anthropology/Archaeology Section
Department of Humanities

J. Scott Whitaker
Department of Physics

To Assistant Professors:

Suzanne Flynn
Department of Mathematics

Andrew C. Fowler
Department of Mathematics

Dwight E. Smith
Athletic Department

Janie Vanpee
Foreign Languages and Literature Section
Department of Humanities

Edith J. Waldstein
Foreign Languages and Literature Section
Department of Humanities

CHANGES OF APPOINTMENT

Keiiti Aki
Robert R. Shrock Professor of Earth and Planetary Sciences in Department of Earth and Planetary Sciences

David L. Akin
International Assistant Professor in Department of Aeronautics and Astronautics

Ali S. Argon
Quentin Berg Professor of Mechanical Engineering in Department of Mechnical Engineering

Nicholas Ashford
Director of Center for Policy Alternatives and Associate Professor of Technology and Policy in School of Engineering

Stephen A. Benton
Associate Professor
Department of Architecture

Thomas A. Barocci
Senior Lecturer
Sloan School of Management

Robert J. Birgeneau
Cecil and Ida Green Professor of Physics in Department of Physics

Michael Bishop
Associate Professor
Department of Architecture

Louis B. D. Braida
Henry Ellis Warren Professor of Electrical Engineering in Department of Electrical Engineering and Computer Science

John F. Brady
Dupont Assistant Professor
Department of Chemical Engineering

Wai K. Cheng
Carl Richard Soderberg Assistant Professor in Power Engineering in Department of Mechanical Engineering

Chryssostomos Chryssostomidis
Director of the MIT Sea Grant Program and Professor of Naval Architecture in Department of Ocean Engineering

Herman Feshbach
Institute Professor and Department Head in Department of Physics

Merton C. Flemings
Department Head
Department of Materials Science and Engineering

Edward Fredkin
Adjunct Professor
Department of Electrical Engineering and Computer Science

Ann Friedlaender
Department Head and Professor in Department of Economics and Department of Civil Engineering

Ted R. I. Greenwood
Lecturer
Department of Political Science

Gary A. Hack
Department Head and Associate Professor in Department of Urban Studies and Planning

Robert H. Halstead
ITT Career Development Assistant Professor of Computer Technology in Department of Electrical Engineering and Computer Science

Trevor A. Hatton
Atlantic Richfield Assistant Professor in Department of Chemical Engineering

James T. Higginbotham
Associate Professor
Department of Linguistics and Philosophy

John M. Hollerbach
Assistant Professor
Department of Psychology

J. Herbert Hollomon
Japan Steel Industries Professor of Engineering in School of Engineering

Pierre A. Humblet
Nippon Electric Company Career Development Associate Professor of Computers and Communication in Department of Electrical Engineering and Computer Science

Henry G. Irwig
Gilbert W. Winslow Career Development Associate Professor in Department of Civil Engineering

Shun Kanda
Lecturer
Department of Architecture

Merrie G. Klapp
Assistant Professor
Department of Urban
Studies and Planning

Frank T. Leighton
Assistant Professor of Applied
Mathematics
Department of Mathematics

John S. Lewis
Visiting Professor
Department of Earth and
Planetary Sciences

Nancy Lynch
Ellen Swallow Richards
Associate Professor of
Computer Science and
Engineering in Department of
Electrical Engineering and
Computer Science

Giorgio A. Mangiarotti
Visiting Professor
Department of Biology

Michael P. Manning
Lecturer
Department of Chemical
Engineering

Leigh McAlister
Assistant Professor
Sloan School of Management

Daniel L. McFadden
Elizabeth P. and James R.
Killian Class of 1926
Professor in Department of
Economics

Frederick J. McGarry
Director of Summer Session and
Professor in Department of
Materials Science and
Engineering

Albert R. Meyer
Cecil H. Green Professor of
Computer Science and
Engineering in Department of
Electrical Engineering and
Computer Science

Steven Mullaney
Assistant Professor
Literature Section
Department of Humanities

Bruce R. Musicus
Class of 1956 Career
Development Assistant
Professor in Department of
Electrical Engineering and
Computer Science

John R. Myer
Department Head and Professor
Department of Architecture

Barry E. Parsons
Associate Professor
Department of Earth and
Planetary Sciences

Anthony T. Patera
Assistant Professor
Department of Mechanical
Engineering

Alician V. Quinlan
Lecturer
Department of Mechanical
Engineering

Dwight E. Smith
Assistant Professor
Athletic Department

Peter H. Smith
Associate Dean of the School
of Humanities and Social
Science and Professor of
History and Department of
Political Science

Charles G. Sodini
Analog Devices Career
Development Assistant
Professor in Department of
Electrical Engineering and
Computer Science

Chong S. P. Sung
Principal Research Associate
Department of Materials
Science and Engineering

Beeke S. Tower
Visiting Scholar
Department of Architecture

Michael S. Triantafyllou
Henry L. Doherty Assistant
Professor of Ocean Utilization
in Department of Ocean
Engineering

Barbara A. Underwood
Lecturer
Department of Nutrition and
Food Science

Christopher T. Walsh
Department Head in Department
of Chemistry and Uncas and
Helen Whitaker Professor in
the Whitaker College

Margaret H. Weiler
Visiting Scientist
Department of Physics

Dorothy E. Westney
Assistant Professor
Sloan School of Management

David N. Wormley
Department Head and Professor
Department of Mechanical
Engineering

Ronald W. Yeung
Visiting Professor
Department of Ocean
Engineering

NEW FACULTY APPOINTMENTS

Professors:

Steven Dubowsky
Department of Mechanical
Engineering

Gerald R. Fink
Department of Biology

Kurt W. Forster
Department of Architecture

Lynn W. Gelhar
Department of Civil
Engineering

Patrick Lee
Department of Physics

Stephen Lippard
Department of Chemistry

Associate Professors:

David R. Clarke
Department of Materials
Science and Engineering

John Dittmer
History Section
Department of Humanities

Terrence L. Tinkel
Department of Ocean
Engineering

Assistant Professors:

Yasser A. al-Tabba
Department of Architecture

David J. Anick
Department of Mathematics

Robert C. Berwick
Department of Electrical
Engineering and Computer
Science

Yohel Camayd-Freixas
Department of Urban Studies
and Planning

Ellen W. Chu
Writing Program
Department of Humanities

Manuel Delgado
Foreign Languages and
Literature Section
Department of Humanities

Edward H. Farhi
Department of Physics

Charles H. Fine
Sloan School of Management

S. James Gates
Department of Mathematics

David K. Gifford
Department of Electrical
Engineering and Computer
Science

George A. Huff
Department of Chemical
Engineering

George A. Kocur
Department of Civil
Engineering

Mark A. Kramer
Department of Chemical
Engineering

Marcia K. McNutt
Department of Earth and
Planetary Sciences

Ralph L. McNutt, Jr.
Department of Physics

Barbara J. Meyer
Department of Biology

Bruce R. Musicus
Department of Electrical
Engineering and Computer
Science

Keith A. Nelson
Department of Chemistry

Steven Pinker
Department of Psychology

James L. Powell
Department of Economics

Jane Roessner
Literature Section
Department of Humanities

Garth Saloner
Department of Economics

Andrei L. Schor
Department of Nuclear
Engineering

John H. Slater
Department of Civil
Engineering

Charles G. Sodini
Department of Electrical
Engineering and Computer
Science

Michael E. Treacy
Sloan School of Management

Dick K. Yue
Department of Ocean
Engineering

Adjunct Professors:

H. Austin Spang, III
Department of Electrical
Engineering and Computer
Science

VISITING FACULTY

Visiting Professors:

Claude J. Allegre
Department of Earth and
Planetary Sciences

John L. Anderson
Department of Chemical
Enginering

M. Vasken Aposhian
Department of Biology

Hugh L. Barnes
Department of Earth and
Planetary Sciences

Jean-Pierre Beauviala
Department of Architecture

Gottfied L. Boehm
Department of Architecture

Graham W. Brawn
Department of Architecture

Frank H. Hahn
Department of Economics

Oliver D. Hart
Department of Economics

Jean P. Ioannides
Department of Ocean
Engineering

Edward M. Kosower
Department of Chemistry

Max V. Mathews
School of Humanities
and Social Science

Jeremiah P. Ostriker
Department of Physics

Andrea Pineau
Department of Materials
Science and Engineering

Remy Prud'Homme
Department of Urban
Studies and Planning

Paul F. Rempp
Department of Chemical
Engineering

Philip G. Saffman
Department of Mathematics

Kenan E. Sahin
Sloan School of Management

Mathukumalli Vidyasagar
Department of Electrical
Engineering and Computer
Science

James E. White
Department of Earth and
Planetary Sciences

Visiting Associate Professors:

James Bisogni
Department of Civil
Engineering

Richard J. Brook
Department of Materials
Science and Engineering

Yao-song Chen
Department of Civil
Engineering

Carlos F. Deganzo
Department of Civil
Engineering

Johan P. Goedbloed
Department of Nuclear
Engineering and Plasma
Fusion Center

David L. Kohlstedt
Department of Earth and
Planetary Sciences

John R. Krenos
Department of Chemistry

Meryl R. Louis
Sloan School of Management

Charles Manski
Department of Civil
Engineering and Department
of Economics

James X. McCloskey
Department of Linguistics
and Philosophy

Jay Meek
Writing Program
Department of Humanities

Patrick A. Purcell
Department of Architecture

A. George Thompson
Department of Mechanical
Engineering

Michael L. Tushman
Sloan School of Management

Juan B. Valdes
Department of Civil
Engineering

Paul R. Warshaw
Sloan School of Management

Visiting Assistant Professors:

Ashim K. Mallik
Department of Mathematics

Stephen M. Paneitz
Department of Mathematics

Dale H. Peterson
Department of Mathematics

Sandro Rambaldi
Department of Meteorology
and Physical Oceanography

James R. Siemon
Literature Section
Department of Humanities

John M. Staudenmaier
Program in Science,
Technology, and Society

AWARD

Hermann Haus
Professor in Department of
Electrical Engineering and
Computer Science; Killian
Award Lecturer for 1982-83

ADMINISTRATION

DEATHS

Patricia A. MacPherson
Administrative Assistant
Sloan School of Management

RETIREMENTS

Alice S. Amdur
Administrative Assistant
Office of the Provost

Jacqueline M. Findlay
Assistant Director of
Corporate Relations
Resource Development/Corporate
Relations

Margaret A. Gibson
Auditor
Office of the Dean for Student
Affairs

Earl M. Harvey
Staff Architect and Principal
Structural Engineer
Physical Plant

Irene H. Henry
Administrative Assistant to
Vice President
Vice President for Resource
Development

Robert J. Holden
Associate Dean and Section
Head, Student Activities
Office of the Dean for Student
Affairs

Marie T. Jeon
Senior Manager, Medical Claims
and Member's Services
Medical Department

Keatinge Keays
Administratve Officer
Department of Ocean
Engineering

William E. Kelley
Budget Director
Budget Office

Mitchell A. Kloza
Senior Accounting Officer
Lincoln Fiscal Office

Robert E. Shaw
Assistant Director
Housing Office

Robert H. Stevens
Purchasing Agent
Department of Purchasing
and Stores

Kimball Valentine
Insurance and Legal
Administrative Office
Treasurer's Office

Charles J. Ward
Senior Staff Accountant
Comptroller's Accounting
Office

RESIGNATIONS

Kenneth R. Auerbach
Programmer/Anaylst
Information Processing
Services

Keith D. Avery
Senior Applications Programmer
Information Processing
Services

Robert R. Babb
Administrative Officer
Office of Laboratory Supplies

Frances H. Bangs
Manager, Class Programs
Alumni Association

Sharon Basco-Koch
Acquisition Editor
MIT Press

Thomas Allen Blackson
Programming Analyst
Information Processing
Services

Peter J. Boisvert
Senior Programming Analyst
Information Processing
Services

Rae K. Burns
Technical Supervisor
Information Processing
Services

Eileen B. Callum
Librarian
Center for Policy Alternatives

Peter M. Cardonna
Applications Programmer
Information Processing
Services

Roberta A. Carrara
Coordinator, Internal
Programs, Alumni Fund
Alumni Association

Sofia Chernin
Programmer Analyst
Information Processing
Services

Marjorie Chryssostomidis
Librarian
Libraries

Melinda A. Costello
Staff Administrator
Department of Purchasing and Stores

Katharine C. Cutting
Administrative Staff
Office of the Dean for Student Affairs

Stephanie M. Demeris-George
Administrative Assistant
Department of Civil Engineering

Mary E. J. DeSesa
Administrative Assistant
MIT Press

Richard H. Dewey
Librarian
Libraries

Judith E. Digennaro
Informaton Retrieval Manager
Alumni Association

Donna L. Dudley
Staff Accountant
Comptroller's Accounting Office

Harris P. Eigabroadt
Supervisor Video Production and Maintenance
Office of the Provost

Sharon K. Everson
Senior Numerical/Statistical Analyst
Informaton Processing Services

Carol J. Finney
Administrative Staff
Office of the President

Sheryn K. Flasher
Applications Programmer
Information Processing Services

David B. Foster
Assistant Contract Administrator
Office of Sponsored Programs

Rosalie Gerut
Assistant to the Director
Program in Science, Technology, and Society

Herman Gilman
Staff Mechanical Engineer
Physical Plant

Ann E. Gollon
Assistant to the Treasurer
Treasurer's Office

Karen H. Goodall
Child Care Administrator
Child Care Office

David E. Griffin
Applications Programmer
Information Processing Services

L. Peter Hamlin
Applications Programmer
Information Processing Services

Carol K. Hanson
Data Base Manager
Office of Facilities Management Systems

Stephen Herzog
Assistant Real Estate Officer
Treasurer's Office

Sylvia Hurtado
Assistant to the Director
Admissions Office

Patricia Joffee
Assistant to Undergraduate Public Policy Program Director
Department of Political Science

Katherine C. Jones
Staff Writer/Editor
Communications Office/ Resource Development

Bruce L. Katz
Associate Acquistion Editor
MIT Press

Clyde E. Kelly
Manager, Information Systems
Industrial Liaison Program

Lawrence W. Killian
Directory Mail Manager
MIT Press

Cynthia L. Konick
Systems Analyst
Information Processing Services

Richard S. Lamson
Systems Programmer
Information Processing Services

Caroline M. Lange
Supervisor, Publications Service
Information Processing Services

Laura G. Lawrence
Senior Applications Programmer
Information Processing Services

John N. Lazarus
Technical Writer
Information Processing Services

Olga Levshin
Programming Analyst
Information Processing Services

Patricia A. Lewis
Financial Administrator
Department of Chemistry

Marjorie S. Lucker
Administrative Officer
Department of Humanities

Arum K. Malik
Programmer Analyst
Information Processing Services

Steven Jules Marcus
Managing Editor
Alumni Association

Elizabeth A. Margutti
Librarian
Libraries

Deborah Lee McCoy
Administrative Assistant
Department of Nutrition and Food Science

Junko E. McLean
Grant and Contract Administrator
Department of Earth and Planetary Sciences

Jeanne M. Najemy
Child Care Administrator
Child Care Office

Marlene Ostrowski
Systems Analyst
Information Processing Services

Rhonda E. Peck
Telethon Coordinator
Alumni Association

Kenneth R. Phillips
Senior Staff Accountant
Office of the Bursar

Daniel Robert Pike
Gallery Manager
Committee on the Visual Arts

Jane H. Powers
Staff Accountant
Comptroller's Accounting Office

Frederick J. Quivey
Assistant Dean for Administration
School of Engineering

Laxmi Rao
Senior Applications Programmer
Office of Facilities Management Systems

Barbara E. Reed
Librarian
Libraries

David S. Rich
Administrative Staff
Consortium on Financing Higher Education

Christine Rinaldi
Administrative Staff
Development Office

Ellen Ruppel-Shell
Staff Writer/Editor
Alumni Association

Nancy L. Russell
Associate Director, Alumni Fund
Alumni Association

Rita L. Russell
Data Base Manager
Office of Facilities Management Systems

Diane P. Scandariato
Publications Manager
Center for Advanced Engineering Studies

Rose S. Scanlon
Conference Coordinator
Office of Facilities Management Systems

Donna Schenkel
Assistant Design Manager
MIT Press

Elizabeth C. Scott
Associate Director
Council for the Arts

Carol Debby Seligson
Regional Director
Alumni Association

Peter S. Shaffer
Applications Programmer
Information Processing Services

Susan J. Sidlauskas
Assistant Curator
Committee on the Visual Arts

Grahame J. C. Smith
Acquisition Editor
MIT Press

Jeffrey Robert Solof
Telethon Coordinator
Alumni Association

Sandra S. Sozanski
Symposium Coordinator
Industrial Liaison Program

Ronald S. Stone
Director, Operations
Alumni Association

Clifford A. Truesdell
Assistant Director
Undergraduate Research Opportunities Program

Vivian Unter Weger
Assistant Director of Finance and Administration
Sloan School of Management

Philippa Warner
Child Care Administrator
Child Care Office

Barbara B. Wollan
Administrative Assistant to the President, Emeritus
Office of the President

APPOINTMENTS

Mary Catherine Albano
Systems Analyst
Information Processing Services

Deborah Alexander
Special Assistant to the Director
Office of Minority Education

Barbara Jane Allen
Assistant Director
Council for the Arts

China Altman
Staff Writer/Editor
News Office

Jennifer G. Aszling
Fine Arts Registrar
Committee on the Visual Arts

Mary Athanis
Administrator
Joint MIT-Woods Hole Program

Martha R. Athens
Administrative Staff
President's House

Ragnhild M. Bairnsfather
Librarian
Libraries

Shirley K. Baker
Assistant Director for Public Services
Libraries

Alison B. Bass
Staff Writer/Editor
Alumni Association

Patricia Bell-Scott
Assistant Equal Opportunity Officer
Office of the President

Sara Mae Berman
Administrative Staff
Office of the Dean for Student Affairs

Kevin Bouchard
Gallery Manager
Committee on the Visual Arts

Karen Brehm
Budget Officer
Fiscal Planning and Budget

Frances E. Brister
Academic Administrative Staff
Department of Chemistry

Randy S. Burge
Publications Manager
Center for Advanced Engineering Studies

Jeanne M. Burke
Assistant to the Bursar
Office of the Bursar

Peter M. Caradonna
Applications Programmer
Information Processing Services

Kenneth Wyjing Chin
Personnel Officer
Personnel Office

Katharine G. Cipolla
Librarian
Libraries

Carole A. Clark
Administrative Assistant
Information Processing Services

Michael F. Collins
Administrative Staff
Superintendent's Office

William T. Conley
Property Auditor
Office of Facilities
Management Systems

Elizabeth Craig-McCormack
Archival/Manuscript Specialist
Libraries

Neil W. Didriksen
Associate Director, Alumni
Fund
Alumni Association

Timothy R. Downes
Staff Accountant
Comptroller's Accounting
Office

Barbara Dullea
Operations Manager, Conference
and Seminar Office
Center for Advanced
Engineering Studies

John P. Dunbar
Administrative Staff
Office of Facilities
Management Systems

Alford Dyson, Jr.
Director, Secondary Technical
Education Program
Office of the President

Daniel T. Engelhardt
Administrative Staff
Office of the Registrar

Patricia J. Finocchio
Data Base Manager
Office of Facilities
Management Systems

Elizabeth Gallant
Staff Accountant
Lincoln Fiscal Office

Amy J. Garfinkle
Archival/Manuscript Specialist
Libraries

Susan P. Gaskell
Senior Personnel Officer
Personnel Office

Kevin J. Gedrich
Assistant to the Manager,
Production Services
Information Processing
Services

Barrie Gleason
Technical Writer
Information Processing
Services

Mary E. Gibson
Assistant Officer
Fiscal Planning and Budget
Office

Esther M. Hanig
Child Care Administrator
Child Care Office

Lyman R. Hazelton
Systems Programmer
Information Processing
Services

Sylvia Hurtado
Assistant to the Director of
Admissions
Admissions Office

W. Scott Johnsen
Coordinator of Computer
Operations
Industrial Liaison Program

Elizabeth S. Johnson
Data Base Administrator
Office of the President

Kenneth Keefe
Systems Analyst
Information Processing
Services

Edith A. Klotz
Staff Accountant
Comptrollers' Accounting
Office

Joanna C. Kosakowski
Administrative Assistant
Sloan School of Management

Susan Kososki
Senior Applications Programmer
Office of Facilities
Management Systems

Christine F. Lamb
Editorial and Production
Manager for Journals
MIT Press

Janet S. Lambert
Director, Course Program
Alumni Association

Michael Leininger
Assistant Roch Librarian for
Reference
Libraries

Marie Ludwig
Technical Writer
Information Processing
Services

Paul MacDonald
Property Auditor
Office of Facilities
Management Systems

Andrew M. MacDougall
Manager of Facility Control
Superintendent's Office

Janet Macy
Systems Analyst
Information Processing
Services

William McLaurin
Director
Office of Minority Education

Jane A. McNichols
Librarian
Libraries

Ronald I. Mendes
Administrative Staff
Superintendent's Office

David L. Millay
Administrative Staff
Superintendent's Office

John E. Miller
Systems Analyst
Information Processing
Services

Margo M. Miller
Staff Administrator
Superintedent's Office

Susan A. Muzio
Conference Coordinator
Office of Facilities
Management Systems

Janice Nagle
Administrative Assistant
Department of Psychology

Jeanne M. Najemy
Child Care Administrator
Child Care Office

Ellen Nangle
Administrative Assistant
Sloan School of Management

Catherine Ormond
Budget Officer
Fiscal Planning and Budget
Office

Rajeshwari R. Patel
Regional Director
Alumni Association

Karen Ann Paulino
Coordinator of Enrollment
Services Operations
Medical Department

Elizabeth E. Pessek
Archival/Manuscript Specialist
Libraries

Jan Popiel
Technical Supervisor
Information Processing
Services

John M. Poverchuk
Area Manager
Information Processing
Services

George F. Prendergast
Coordinator
Office of Sponsored Programs

Michael J. Quinlan
Administrative Staff
Physical Plant

William C. Remsen
Academic Administrative Staff
Libraries

David S. Rich
Administrative Staff
Office of the President

Carol E. Roberts
Information Retrieval Manager
Alumni Association

Gianna Sabella
Administrative Staff
MIT Press

Cristina Sanmartin
Acquisition Coordinator
MIT Press

Julia M. Sawabini
Texts and Exhibits Manager
MIT Press

Carmela R. Sciandra
Programming Analyst
Industrial Liaison Program

David Shaffer
Programmer Analyst
Information Processing
Services

Barbara Simmons
Archival/Manuscript Specialist
Libraries

Ruth V. Spear
Coordinator of the Humanities
Undergraduate Office
School of Humanities

Ronald P. Suduiko
Special Assistant, Office of
the Chairman
Office of the President

Robert L. Van De Pitte
Assistant Director, Office of
the Chairman
Office of Sponsored Programs

Ellen A. Weiss
Applications Programmer
Information Processing
Services

Mary E. Westlund
Manager, Marketing Services,
Self Study Program
Center for Advanced
Engineering Studies

Robert E. Zaret
Programmer Analyst
Information Processing
Services

Julie Zuckman
Promotion and Advertising
Manager for Journals
MIT Press

CHANGES

Sarah Abrams
Staff Writer/Editor
Communications/Resource
Development Office

Dorothy G. Adler
Coordinator for Alumni
Selection and Recognition
Processes
Alumni Association

Barbara Alpert
Senior Systems Analyst
Information Processing
Services

Henry B. Antinarelli
Administrative Staff
Superintendent's Office

Jeffrey R. Armes
Administrative Staff
Food Services

Anne E. Armitage
Academic Administrative Staff
Department of Nutrition and
Food Science

Martha R. Athens
Administrative Staff
President's House

Walter J. Bagley
Administrative Staff
Housing Office

James F. Baker Jr.
Administrative Staff
Campus Police

Kathleen M. Barrett
Administrative Staff
Campus Information Services

Russell Beharry
Administrative Staff
Food Services

Paul L. Bergonzi
Asistant to the Manager
Credit Union

Sara Mae Berman
Administrative Staff
Office of the Dean for Student
Affairs

Benjamin A. Bernick
Administrative Staff
Food Services

Scott A. Berry
Administrative Staff
Food Services

Martha L. Bertrand
Assistant Director
Communications/Resource
Development Office

Lee C. Birks
Administrative Staff
Housing Office

Ellen A. Bolick
Administrative Staff
Technology and Policy Program

Paul R. Bragger
Administrative Staff
Food Services

Peter Brown
Assistant Dean for Student
Affairs, Residence and Campus
Activities
Office of the Dean for Student
Affairs

Jill A. Brown
Academic Administrative Staff
Department of Biology

Catherine M. Burke
Administrative Staff
Physical Plant

Karen R. Bushold
Academic Administrative Staff
Department of Nutrition and Food Science

Cheryl Ann Butters
Academic Administrative Staff
Department of Electrical Engineering and Computer Science

John R. Butts
Administrative Staff
Superintendent's Office

Ronald J. Byrnes
Administrative Staff
Superintendent's Office

Alfred Cabral
Administrative Staff
Campus Police

Seibert O. Callender
Administrative Staff
Superintendent's Office

Joseph A. Caloggero
Academic Administrative Staff
Department of Mechanical Engineering

George E. Carney
Administrative Staff
Superintendent's Office

Susan E. Cavanaugh
Administrative Staff
Food Services

Richard Cerrato
Assistant Director
Housing and Food Services

Phyllis Cerrone
Administrative Staff
Graphic Arts Services

Marshall V. Cheverie
Administrative Staff
Campus Police

Barbara S. Chuck
Administrative Staff
Office of the Dean for Student Affairs

Rudolofo Cid
Administrative Staff
Information Processing Services

Debra E. Cobb
Administrative Staff
Comptroller's Accounting Office

Katherine R. Cochrane
Administrative Staff
Office of the Dean for Student Affairs

Theodore F. Coleman
Academic Administrative Staff
Department of Physics

Michael F. Collins
Administrative Staff
Superintendent's Office

Richard M. Collis
Administrative Staff
Graphic Arts Services

Donald A. Collupy
Administrative Staff
Graphic Arts Services

John P. Corcoran
Administrative Staff
Superintendent's Office

Lisa Cornelisse
Information Specialist
Libraries

Lillian Cornwall
Administrative Staff
Superintendent's Office

Paula B. Cronin
Director of Alumni Relations and Information
Sloan School of Management

Janet L. Cronin
Administrative Assistant
Industrial Liaison Program

Daniel Crovo
Administrative Staff
Superintendent's Office

Daniel A. Crovo
Administrative Staff
Superintendent's Office

Virginia A. Cruz
Administrative Staff
Safety Office

Marion A. Curley
Academic Administrative Staff
Department of Chemistry

Katharine C. Cutting
Administrative Staff
Office of the Dean for Student Affairs

Mary Frances Daly
Administrative Staff
Quarter Century Club

Thomas L. Davenport
Applications Programmer
Department of Materials Science and Engineering

Robert M. Davine
Senior Applications Programmer
Information Processing Services

Alan G. Davis
Administrative Staff
Physical Plant

Maureen C. DeCourcey
Assistant Bursar
Office of the Bursar

Ann F. Delaney
Administrative Staff
Lincoln Fiscal Office

Ralph H. DeMarco
Administrative Staff
Superintendent's Office

Theresa Demeris
Academic Administrative Staff
Department of Civil Engineering

Margaret E. DePopolo
Librarian
Libraries

Kenneth F. Deroeck
Administrative Staff
Food Services

June E. Desmarais
Administrative Staff
MIT Press

Cesare A. DiFava
Administrative Staff
Superintendent's Office

Marie T. DiFonte
Administrative Staff
Food Services

Steven M. Dimond
Administrative Staff
Graphic Arts Services

Kenneth Donaghey
Administrative Staff
Housing Office

Edward P. Donnelly
Administrative Staff
Comptroller's Accounting Office

John P. Dunbar
Administrative Staff
Office of Facilities Management Systems

Alexander Eccles
Administrative Staff
Superintendent's Office

Katherine R. Eisenhaure
Program Manager
Whitaker College of Health Sciences, Technology, and Management

Josephine Eisner
Administrative Staff
Office of the Registrar

Albert C. Epstein
Administrative Staff
Food Services

Cathleen M. Feeley
Administrative Staff
Office of the Bursar

Susan M. Fennelly
Academic Administrative Staff
Department of Aeronautics and Astronautics

Robyn L. Fizz
Academic Administrative Staff
Department of Nutrition and Food Science

David T. Flett
Administrative Staff
Superintendent's Office

Winston E. Flynn
Associate Registrar
Office of the Registrar

Michael W. Foley
Administrative Staff
Superintendent's Office

William J. Forti
Administrative Staff
Superintendent's Office

Martha L. Fox
Academic Administrative Staff
Department of Mathematics

Mario J. Fresina
Administrative Staff
Environmental Medical Service

Paul J. Gabriel
Academic Administrative Staff
Department of Chemistry

James F. Galvin
Administrative Staff
Office of the Bursar

Elizabeth Gandolfo
Administrative Staff
Food Services

E. Peggy Garlick
Academic Administrative Staff
Department of Mechanical Engineering

Jeannette L. Gerzon
Administrative Staff
Career Planning and Placement

Joseph D. Gibbs
Administrative Staff
Superintendent's Office

George F. Gibney
Administrative Staff
Superintendent's Office

William Gilbert
Computer Systems Manager
Whitaker College of Health Scences, Technology, and Management

Anne P. Glavin
Administrative Staff
Campus Police

Michael Glover
Benefits Associate
Personnel Office

Steven D. Goode
Assistant Director
Office of Sponsored Programs

Vincent S. Goodridge
Administrative Staff
Campus Police

Noelle B. Gove
Administrative Staff
Office of the Registrar

Anne M. Grazewski
Administrative Officer
Department of Political Science

Donald H. Green
Administrative Staff
Physical Plant

Nancy Greenhouse
Texts and Exhibits Manager
MIT Press

Richard T. Greenough
Administrative Staff
Superintendent's Office

Frederick P. Gross
Assistant Director
Industrial Liaison Progam

Margaret Gutowski
Academic Administrative Staff
Department of Nutrition and Food Science

Sandra L. Hackman
Administrative Staff
Alumni Asociation

Robert H. Hagerty
Administrative Staff
Superintendent's Office

Charles Joseph Hale
Administrative Staff
MIT Press

Donna S. Hall
Academic Administrative Staff
Department of Earth and Planetary Sciences

Brenda L. Hambleton
Assistant Director
Admissions Office

Donald E. Heller
Staff Administrator
Department of Purchasing and Stores

Thomas R. Henneberry
Administrative Officer
Treasurer's Office

Laura C. Herring
Administrative Staff
Office of the Dean for Student Affairs

Ellen N. Hoffman
Assistant Director of Communications
Communications/Resource Development Office

Donald W. Holladay
Administrative Staff
Information Processing Services

Constance M. Holland
Administrative Staff
Faculty Club

George E. Hosker
Administrative Staff
Housing Office

Mary J. Hovnanian
Administrative Staff
Military Science

Lindsey V. Humes
Administrative Staff
Development Office

Elizabeth C. Hurlbert
Administrative Staff
Office of Sponsored Programs

Ralph V. Jackson
Administrative Staff
Superintedent's Office

Sharon Lee Jackson
Administrative Staff
Medical Department

Micheline E. Jedrey
Acting Head, Rotch Library
Libraries

Charles T. Jennings
Administrative Staff
Superintendent's Office

Roland R. Jensen
Administrative Staff
MIT Press

Peter Johnson
Administrative Staff
Superintendent's Office

Estil Jones
Administrative Staff
Superintendent's Office

Marie Kalenderian
Senior Applications Programmer
Information Processing
Services

Robert K. Kaynor
Associate Planning Officer
Planning Office

Mary M. Kelly
Assistant to the Director for
the Freshman Process and Data
Base Mangement
Admissions Office

Susan L. Kendall
Administrative Staff
Office of the President

Luise Keohane
Administrative Staff
Housing Office

Carla W. Kirmani
Administrative Officer
Program in Science,
Technology, and Society

Maria Kittredge
Administrative Assistant
Department of Civil
Engineering

Sandra Lynn Knight
Administrative Staff
Alumni Association

Heather D. Kraemer
Administrative Officer
Center for Transportation
Studies

David Laughridge
Administrative Staff
Graphic Arts Services

David Lawless
Systems Programmer
Information Processing
Services

Reta Lee
Staff Accountant
Office of the Dean for Student
Affairs

Thomas M. Lynch
Administrative Staff
Environmental Medical Service

Genevieve MacLellan
Administrative Staff
MIT Press

Emily F. Magazzu
Administrative Staff
Sloan School of Management

Norman H. Magnuson
Administrative Staff
Housing Office

James F. Mahoney, Jr.
Administrative Staff
Campus Police

William M. Malone
Administrative Staff
Athletic Department

Maurice McDermott
Senior Systems Analyst
Information Processing
Services

Denis J. McFadden
Senior Applications Programmer
Information Processing
Services

John A. McIntosh
Administrative Staff
Food Services

Marilyn A. McMillan
Manager
Information Processing
Services

William McRitchie
Administrative Staff
Superintendent's Office

James F. McTaggart
Administrative Staff
Superintendent's Office

Judy A. Melagrano
Administrative Staff
Medical Department

Norma Mele
Administrative Staff
Housing Office

Stanley J. Michalak
Systems Analyst
Information Processing
Services

David L. Millay
Administrative Staff
Superintedent's Office

Eleanor J. Miller
Administrative Staff
Office of the Registrar

Stephen P. Miscowski
Administrative Staff
Superintendent's Office

Susan L. Mitchell-Hardt
Administrative Staff
Office of the Provost

Joseph Molineaux
Administrative Staff
Campus Police

Guy J. Morac
Administrative Staff
Food Services

Gail M. Morchower
Academic Administrative Staff
Department of Physics

Errol W. Morrison
Administrative Staff
Information Processing
Services

Paul Motroni
Administrative Staff
Superintendent's Office

Cornelius J. Murphy
Administrative Staff
Superintendent's Office

Joanne E. Murray
Academic Administrative Staff
Department of Mathematics

Stanley Oblachinski
Administrative Staff
Endicott House

Donald J. Olson
Administrative Staff
Superintendent's Office

Leo Osgood, Jr.
Assistant Dean, Student
Assistance Services
Office of the Dean for Student
Affairs

Michael O'Connell
Administrative Staff
Department of Materials Science and Engineering

Teresa M. O'Connor
Administrative Staff
Housing Office

Lucille A. O'Hehir
Administrative Staff
Food Services

Karin P. O'Loughlin
Academic Administrative Staff
Libraries

Frank H. Palmer
Administrative Staff
Physical Plant

Joseph W. Palmer
Administrative Staff
Superintendent's Office

Linda L. Patton
Administrative Staff
Housing Office

Gloria E. Payne
Administrative Staff
Office of the Provost

Albert Pellecchia
Administrative Staff
Graphic Arts Services

Muriel A. Petranic
Academic Administrative Staff
Dean of Engineering Office

Austin H. Petzke
Administrative Staff
Superintendent's Office

Kenneth R. Phillips
Senior Staff Accountant
Office of the Bursar

Barry Pieciul
Administrative Staff
Housing Office

Anne M. Pitcher
Administrative Staff
Food Services

Leo S. Plagenza
Administrative Staff
Superintendent's Office

Jan Popiel
Technical Supervisor
Information Processing Services

John Preston
Assistant Director for Marketing
Industrial Liaison Program

John Prialaga
Administrative Staff
Housing Office

Terri Priest
Administrative Staff
Campus Information Services

Fredda S. Purgalin
Administrative Staff
MIT Press

Judith A. Quimby
Academic Administrative Staff
Department of Nutrition and Food Science

Robert T. Ramsay, Jr.
Administrative Staff
Food Services

Marion D. Redonnet
Administrative Staff
Alumni Association

George S. Reid
Administrative Staff
Superintendent's Office

James Repa
Systems Programmer
Information Processing Services

Milda B. Richardson
Academic Administrative Staff
Department of Physics

Christine M. Rinaldi
Administrative Staff
Development Office

Harold W. Roberts
Admini,strative Staff
Superintendent's Office

Margaret Mary Rodger
Administrative Staff
Food Services

Teresa M. Rodrigues
Administrative Staff
Comptroller's Accounting Office

Janet Romaine
Assistant Dean for Administration
School of Humanities and Social Science

Peter A. Rossetti
Administrative Staff
Superintendent's Office

Phyllis Ruby
Academic Administrative Staff
Department of Mathematics

Paul C. Rudack
Administrative Staff
Superintendent's Office

John F. Rutledge
Administrative Staff
Housing Office

Donna R. Savicki
Assistant Dean of Engineering
School of Engineering

Jeffrey I. Schiller
Systems Programmer
Information Processing Services

Ralph J. Scholl
Administrative Staff
Graphic Arts Service

Laura E. Scott-Stout
Assistant Director
Industrial Liaison Program

John J. Shea, Jr.
Administrative Staff
Office of Laboratory Supplies

Pamela C. Shepherd
Administrator
Department of Economics

Robert A. Sherwood
Asssociate Dean for Student Affairs, Residence and Campus Activities
Office of the Dean for Student Affairs

Manuel L. Silva
Academic Administrative Staff
Department of Electrical Engineering and Computer Science

Susan R. Smith
Assistant to the Department Head
Department of Urban Studies and Planning

Robert S. Solakoff
Administrative Staff
Campus Police

Murray L. Somerville
Academic Administrative Staff
Department of Chemistry

Linda S. Stantial
Director of Masters' Placement
Sloan School of Management

Robert G. Stedman
Administrative Staff
Superintendent's Office

Charlene Steele
Academic Administrative Staff
Libraries

John H. Stowe
Administrative Staff
Superintendent's Office

Stanley W. Sundstrom
Senior Systems Analyst
Information Processing
Services

Joseph W. Sullivan
Administrative Staff
Campus Police

Judith Syatt
Administrative Staff
Office of the Bursar

William G. Tanner
Administrative Staff
Physical Plant

Anthony L. Tedesco
Administrative Staff
Physical Plant

Richard M. Thomas
Academic Administrative Staff
Microreproduction Service

Michael S. Thornton
Publication Service Supervisor
Information Processing
Services

John E. Tocio
Administrative Staff
Housing Office

Armando Tontodonato
Academic Administrative Staff
Libraries

William M. Toscano
Assistant to Administrative
Officer
Harvard/MIT Division of Health
Sciences and Technology

Mary J. Tsafonias
Administrative Staff
Office of the Bursar

Roger H. Wallin
Administrative Staff
Housing Office

Cynthia Ware
Communicatons Coordinator
School of Architecture and
Planning

Leo J. Webb
Administrative Staff
Superintendent's Office

Charles O. Webber
Administrative Staff
Physical Plant

Roberta R. Welch
Administrative Staff
Office of the Registrar

Lillian H. Whelpley
Administrator, Information
Center
Campus Information Services

Lucile N. White
Administrative Staff
Housing Office

Anne Whitman
Administrative Staff
Office of the President

Jane Wilbur-Brown
Academic Administrative Staff
Department of Physics

Charles E. Wilkins
Administrative Staff
Superintendent's Office

Mark Wilson
Administrative Staff
Campus Information Services

Celia C. Wilson
Administrative Staff
MIT Press

Rodger E. Wilson
Administrative Staff
Superintendent's Office

Frank R. Winsor
Administrative Staff
Superintendent's Office

Kenneth H. Wolff
Administrative Staff
Housing Office

Robert Z. Wright
Administrative Staff
Comptroller's Accounting
Office

Stephen H. Young
Academic Administrative Staff
Division of Comparative
Medicine

Provost

Center for Advanced Visual Studies

The Center for Advanced Visual Studies (CAVS) was dedicated in March, 1968. Its 15th year was marked by a variety of projects in national and international contexts and highlighted by many forms of recognition given to the Center and to its Fellows.

The SKY ART Conference '82 was hosted by the international festival, Brucknerfest/ARS ELECTRONICA in Linz, Austria, in September 1982. It was chaired by Professor Yash Pal, secretary general of the 1982 UNISpace Conference of the United Nations, and it was directed by Professor Otto Piene with Elizabeth Goldring, co-director. A stage version of the sky opera, Icarus, by Paul Earls, Otto Piene, and Ian Strasfogel was produced and performed; eminent artists and scholars met at the Conference; and sky and telecommunication events happened throughout the four-day program. Some participants: Institute Professor Emeritus Gyorgy Kepes, founding director of CAVS, multimedia artists Nam June Paik and Charlotte Moorman; sky artists Joe Davis, Dale Eldred, Rockne Krebs, Tom Van Sant. The 1982 Conference generated a strong echo in press and TV media.

CAVS produced a new First Night multimedia performance series involving stage musicians and lasers and inflatables by Paul Earls and Otto Piene to a 5,000-person audience at Boston Hynes Auditorium for the changing of the year, 1982/83. Many CAVS Fellows and Master of Science in Visual Studies (SMVisS) graduate students were participating artists.

For the summer of 1983 the Boston Institute of Contemporary Art organized "Boston Now," a survey of artistic energies of significant presence and recent history. CAVS artists included were Betsy Connors, Luc Courchesne, Vin Grabill, Bernd Kracke, and Aldo Tambellini.

The Center's work encompasses many forms of artistic exploration of art-science-technology for environmental installation, performance, developmental media, subjective telecommunication, sky art. Joe Davis continued his work towards artistic space shuttle payloads; Guenther Schneider-Siemssen organized an international conference, "Die Buehne der Zukunft" (the future stage) in Salzburg, Austria, with emphasis on the role of holography, laser and laser video disc projection, inflatables; a CAVS group under Rus Gant and Vin Grabill produced the first "Centerdisc": a survey of CAVS media/video work of more than 15 years; Ian Strasfogel staged Kandinsky's "Der Gelbe Klang" (The Yellow Sound) at the Alte Oper, Frankfurt, Germany; Christopher Janney, with his "Sonic Pass," participated in "Wall-to-Wall John Cage" to celebrate John Cage's 70th birthday at Symphony Space, New York, New York; Bruno de Lard has prepared a large-scale aeolic wind harp installation commissioned by the City of Aix-en-Provence, France; Todd Siler had a one-man show at the Gallery Taka Gi in Nagoya, Japan. Piotr Kowalski installed his 1982 Centre Pompidou, Paris, exhibition at the Hara Museum of Contemporary Art in Tokyo in 1983 - which coincided with Professor Piene's one-man show at the Galerie Watari in Tokyo.

Besides major grants for CAVS projects from LIVA (Linzer Veranstaltungsgesellschaft) and the USIA for the SKY ART Conference '82, sponsorship has been obtained for the 1983 SKY ART Conference in Munich, Germany, from the City of Munich, Bayrische Motorenwerke (BMW), and Digital Equipment Corporation. CAVS received a grant from the City of Paris for the preparation of the Center's portion of the ELECTRA '83 exhibition at the Musée d'art moderne de la ville de Paris in 1983/84.

Major prizes have been given to or won by CAVS artists: Mr. Kowalski received the Grand Prix Nationale for Sculpture 1982 in France. He also won an environmental art competition for a plaza at La Défense in Paris. Professor Piene was the artist of the Viguier/Jodry architects team which won first prize at the Tête de Défense international competition in Paris. With a CAVS/MIT group he won third prize in an environmental/architectural competition for two new ministries in Bonn, Federal Republic of Germany. Joan Brigham and Mr. Earls, with Professor Piene, image consultant, were winners of the International Water Sculpture Competition for the 1984 Louisiana World Exposition (New Orleans) with a proposal for a laser/water fountain. Mr. Earls, with the Boston Musica Viva, won a WBZ-TV "You Gotta Have Arts" grant for a new United States production of the sky opera, Icarus.

Other awards: New England Foundation Grant to CAVS for a travelling Sky Art Exhibition with a sky art laser video disc; to Beth Galston: Project Completion Award, Massachusetts Council on the Arts and Humanities; to Bernd Kracke: The Artists Foundation, Video Fellowship, 1983.

Numerous publications by Fellows originated at CAVS. Many articles appeared in print, and media comments and features were aired on TV nationally and internationally about individual and group work at the Center.

The Center's collaboration in the SMVisS program of the School of Architecture and Planning/ Department of Architecture resulted in several theses: Sharon Dunn, "Optical Performance;" Greg Garvey, "Labyrinths" (about computer-controlled, visitor-activated mazes); Jon Jeibmann, "A Light Emitting Object and Its Environment" (about computer-timed light chains); Sally Weber, "Sunlight and the Use of Holographic Diffraction Grating: An Environmental Perspective."

OTTO PIENE

Center for Cognitive Science

1. Introduction

During the academic year, the Center for Cognitive Science initiated or continued a variety of programs designed to foster interdisciplinary research in human cognition. These include the development of the Human Subjects Laboratory, a program for visiting scientists and postdoctoral fellows, an affiliates program, a members program, a graduate fellowship support program, a series of seminars and colloquia, an Occasional Paper publications program, and a program of financial support for research initiatives within the Center. Each of these activities is coordinated through the Center Working Group, which, by means of a committee structure, reviews all proposals and approves expenditures for those programs judged worthy of support. The committees through which the Center activities are coordinated are: (1) the Computational Development Committee, (2) the Research Proposal/Review Committee, and (3) the Visitor Selection Committee. These committees are responsible for the various activities described next.

2. The Laboratory

With the appointment of Dr. Steven Pinker, the Center, in conjunction with the Department of Psychology, successfully concluded a nationwide search for someone who would plan and project research directions for the laboratory and would also be integrally involved in the academic programs of the Institute.

Dr. Pinker, in the first year of his appointment (joint with the Department of Psychology), had an important impact on the shape of the laboratory. Both he and Allan Doyle, the Center's Systems Manager, have been responsible for the achievement of a number of important milestones during the past year, including the development of a version of the 'C' programming language that allows an experimenter to conceptualize the flow of the control in his or her experiment in terms of a state transition network, and then to translate that network directly into a computer program. That program, edited and debugged on the large computer, is then down-loaded to one of the smaller machines, which controls the experiment in real time in accordance with the experimenter's intentions. This setup allows experiments to be run using any combination of tape-recorded speech, projected slides, alphanumeric text on video displays, and subjects' key-pressing or spoken responses, in any temporal relationship. In many cases up to five subjects can be run in an experiment simultaneously. This facility has been running effectively for the past two months and represents an important enhancement of laboratory facilities.

3. Research

Research was supported in the following areas: (1) face recognition in brain-damaged patients, (2) auditory word recognition, and (3) Warlpiri sentence production. In addition, support for collaborative work in vision and phonological theory was provided. The Center also undertook responsibility for providing resources for the planned laboratory subject to be offered in the undergraduate Cognitive Science program. These resources will include space for up to five terminals and access to the PDP 11/44 for experimental modeling. The Center will provide funds for a newsletter associated with this important educational venture.

4. The Visitors Program

During the academic year, the Center supported three postdoctoral fellows: one in psycholinguistics, one in semantics, and one in speech perception. It also hosted eight visiting scientists: one in child language acquisition, one in philosophy, one in linguistics, and five in various branches of psychology.

The Center also supported a small number of predoctoral fellows: two in electrical engineering and computer science, one in linguistics, one in philosophy, and two in psychology. This program will not be available in its present form in the coming year. Instead, support will be closely linked to specific research projects within the Center and, consequently, will be dealt with through requests to the Research Proposal/Review Committee.

5. The Affiliates Program

The Center continued to maintain an affiliates program whereby individuals associated with Center work are given formal status with the Center although they do not work at MIT. Affiliates are individuals who are working actively in the field or who are observers of the field and wish to have Center affiliation. Individuals in this category are reviewed on a yearly basis. At present there are 15.

6. The Members Program

To further support the intellectual goals of the Center, a members program was designed. The program brings people in the MIT community whose interests significantly overlap Center interests into formal affiliation with the Center. At present, the members are Professors Ned Block, Jerry Fodor, and James Higginbotham (Linguistics and Philosophy); Professors Emilio Bizzi, Jeremy Wolfe, and Neal Cohen (Psychology); and Professor Judah Schwartz (Electrical Engineering and Computer Science).

7. Seminars

The Center continued to support two kinds of seminars. The first is a bi-weekly seminar, The Center for Cognitive Science Seminar Series. This series is open to the community at large and is devoted to papers on a variety of topics relevant to the Center. During the academic year, there were eight seminar programs. Approximately 500 people from the community at large attended these seminars.

The second series, arranged in collaboration with the Department of Psychology, is a lunchtime talk series devoted to topics more specifically focussing on experimentation in natural language processing. During the past year approximately 14 such seminars were held.

8. The Occasional Paper Program

The series of occasional papers distributed by the Center attempts to inform fellow workers in the field of important current research undertaken at the Center. To date 22 occasional papers have been published, a number of which were written by visitors to the Center and represent work accomplished during their stay here.

9. Publications

Since its inception, the Center, by making its resources available to visiting scientists, postdoctoral fellows, predoctoral fellows, Center members, and other affiliated faculty, has supported a variety of publications. To date some 25 articles have been published with Center support. In addition, four books were produced during the past year with Center support: Clements, G.N., and Keyser, S.J. "CV Phonology," Linguistic Inquiry Monograph Series No. 9, MIT Press: Cambridge, Mass., (forthcoming, September 1983); Fodor, J.A. Modularity of Mind, MIT Press/Bradford Books: Cambridge, Mass., 1983; Mehler, J., and Fox, R. "Neonate Cognition: Beyond the Blooming, Buzzing Confusion," LEA Publishers: Hillsdale, New Jersey (forthcoming, 1983); Pinker, S. "Language Learnability and Language Development," Harvard University Press: Cambridge, Mass. (forthcoming, 1983).

SAMUEL JAY KEYSER

Center for International Studies

Contemporary policy issues with a strong technological component, generally but not exclusively international, continued to be the focus of the program of the Center for International Studies during the past year. The Center, under its director Professor Eugene B. Skolnikoff, continued its role of bringing together faculty and advanced graduate students from the social sciences and from the engineering and scientific disciplines to explore the interaction of technological developments and public policy. Although the Center does not have its own teaching program, its programs have been designed to maximize their contributions to graduate and undergraduate study at the Institute and to provide support to MIT students. Major program areas, each described below, included arms control and defense, Japanese science and technology, risk management, political development, and science and technology policy, along with work in such areas as energy and transportation.

Questions relating to arms control and defense policy remained major foci of the Center's program. In addition to supporting the students and faculty of a graduate program in that field in the Department of Political Science, the Center's program under the direction of Professor Jack Ruina, Department of Electrical Engineering and Computer Science, carried out research in a number of areas. Professor George Rathjens, Department of Political Science, directed a study of nuclear programs of the Islamic states of the Middle East and North Africa to assess their capability and interest in nuclear weapons development. This work was supported by the Office of Technology Assessment of the US Congress. Professor Ruina directed studies on the kinds of missile capability a country could develop based on commercial hardware available from other than US or Soviet sources, and on international transfer of technologies with military relevance. These studies were supported by the US Arms Control and Disarmament Agency. A new area of long-term research, which also has led to the offering of new courses, was undertaken by Professor Stephen Meyer, Department of Political Science, who has been exploring Soviet defense decisionmaking and military research and development; his work has been supported by the Ford Foundation and the Advanced Research Projects Agency of the Department of Defense. Professor Ted Greenwood, Department of Political Science, began a study on issues relating to US naval forces in the Mediterranean as they bear on the strategy of the North Atlantic Treaty Organization and US Middle East and Persian Gulf contingencies. Dr. Ashton Carter, Postdoctoral Fellow at the Center for International Studies, carried out studies on military uses of space. Dr. Carter, along with Professors Rathjens and Ruina, is collaborating with the Brookings Institution on a study of ballistic missile defense. This will result in a volume early next year which will contribute to informed discussion of what seems likely to be a major public policy issue. In addition to this faculty-directed research, the thesis research of the degree candidates associated with the program constitutes important research products.

The arms control and defense study program has been supported by the Ford Foundation and the Buffett Foundation, as well as receiving grants for specific projects. In January, MIT created a new endowment fund entitled "International Security and Arms Control" to support faculty and students working in this area. At year's end, the Center took the initiative of exploring with other parts of the Institute the feasibility of creating an umbrella coordinating Committee on Arms Control, Disarmament, and Defense Policy Studies at MIT to link existing major teaching and research programs and to provide a framework for stimulating continued growth of teaching and research in this field.

During the closing months of the year, plans were completed for a two-week summer course on nuclear weapons and arms control for faculty from four-year liberal arts colleges. The course, developed jointly by the Center for International Studies and the Center for Science and International Affairs (CSIA) at Harvard University, has been funded by the Alfred P. Sloan Foundation. Faculty teaching in the course include, from MIT, Professors Ruina, Rathjens, Greenwood, and Meyer, Dr. Carter, and Professor William W. Kaufmann, Department of Political Science, and, from the CSIA, Professors Paul Doty, Albert Carnesale, and Michael Nacht. The Center for International Studies has also been working with the MIT Science, Technology, and Society (STS) Program to develop a videotaped course, covering the same material, available for broader distribution; a grant to cover the costs of initiating such a program was made to STS by the Alfred P. Sloan Foundation.

The high reputation enjoyed by the Center's arms control and defense policy program has attracted visiting scholars to the Center. This past year, LTC George Criss, US Air Force (USAF); Professor Dina Spechler, Hebrew University of Jerusalem; Cristann Gibson, Ph.D. candidate at the University of Denver; and Andrew Goldberg, Ph.D. Candidate at Columbia University, were in residence. The latter three were recipients of awards from the Ford Foundation to encourage individuals to develop combined expertise in Soviet studies and in defense policy. Col. Criss was part of the Air Force Associate's Program, a USAF effort to provide a year in an academic setting to promising young officers.

Professors Skolnikoff and Richard Samuels, Department of Political Science, continued over the year to develop the US/Japan Science and Technology Program. Professor Samuels assisted nine young MIT interns to find placement in Japanese industry and laboratories for a year of on-the-job exposure to Japanese scientific and technological research and development. Efforts were continued during the year, with high hope of success, to raise the funds needed to increase the number of such internships and to place them on a continuing basis. During the past year, support was provided by the International Business Machines Inc. and AMF Inc. In addition, the program worked with MIT faculty seeking to establish collaborative relations with Japanese counterparts, served as a focal point at MIT for growing

student and faculty interest in Japan, and facilitated the visit of Japanese scholars to the campus. In January, the program hosted a conference of academic, industrial, and government specialists on the problem of acquiring information in the United States on Japanese science and technology. The session, with funding coordinated by the US Department of State, led to plans for an ongoing effort to expand nationwide data collection programs and to identify critical areas in which growth is essential. Funds for this continuing activity are being sought.

Communications policy has been a central part of the Center's program for the past thirty years. Professor Ithiel de Sola Pool, Department of Political Science, continued to direct the Center's collaboration in the MIT Research Program on Communication Policy, with the Center for Advanced Engineering Study, the Center for Policy Alternatives, the Laboratory for Computer Science, and the Laboratory for Information and Decision Systems. A major achievement of the program in the past year has been to fund a second career-development chair, to which Professor Charles Jonscher has been appointed jointly by the Sloan School of Management and the Department of Political Science; another career-development chair in communications policy was awarded to Professor Russell Neuman, Department of Political Science.

These three faculty have conducted a number of research projects in the communications field, including a study directed by Professor Pool, funded by the US Agency for International Development, on the use of satellite broadcasting systems in agricultural development efforts in remote rural areas. With a grant from the Xerox Corporation, Professor Pool also directed the updating of a previous census of US communications flows in seventeen public media and its expansion to include internal business and administrative communications. This was part of a continuing study of communications flows being carried out jointly with the Research Institute on Telecommunications and Economics in Tokyo. Professor Pool and Dr. Richard Solomon, a consultant to the Center for International Studies, have begun work on a videotaped history of modern computer technology, with funding from the Alfred P. Sloan Foundation; this study will capture information on critical developments directly from individuals who were directly involved, many of them at MIT. The National Science Foundation sponsored a workshop organized by Professor Pool in the summer of 1982 on the measurement of communications flows in society. Professor Pool also directed studies on the modernization of the Voice of America transmitter network for the US International Communications Agency and on the potential integration of academic data bases into the videotext system of The Boston Globe. Professor Jonscher's work concentrated on modelling the information economy: looking at increases in both information technology and labor and trying to explain the increases, understand their implications, and explore the ways in which information resources have been allocated. This study, along with other aspects of the Research Program on Communications Policy, was funded by a consortium of sponsors that included American Telephone and Telegraph, International Telephone and Telegraph, International Business Machines, Hughes Aircraft, Alarm Devices Manufacturing Company, Citibank, the Sloan Foundation, the Markle Foundation, and the Times-Mirror Corporation.

Professor Neuman continued during the past year his work on the future of mass audiences, seeking to develop a multimedia model of the information/entertainment demand over the next two decades and to link that demand with the opportunities created by changing communications technology. This work is funded by the Columbia Broadcasting System, Time Inc., Warner Communications Inc., and the Washington Post Company.

The MIT faculty seminar on health, safety, and environmental risk management continued to meet during the year to discuss ongoing research on various aspects of the detection, control, mitigation, and response to risk. Several pilot projects have been begun. Professor Steven Tannenbaum and Dr. Laura Green, both in the Department of Nutrition and Food Science, started work on new methods to detect at an early stage negative responses to toxic substances; they plan also to address the question of how such knowledge can be utilized in the management of environmental and health risks. Professors Greenwood and Gregory Baecher, Department of Civil Engineering, began a study of how geological information has been utilized in assessing the risks of such large undertakings as dam siting. Professors Lawrence Bacow and Joseph Ferreira, both Department of Urban Studies and Planning, initiated an inquiry into how communities deal with information about risk in acting on proposals for siting hazardous waste treatment facilities. The question of how the legal system has dealt with the issue of compensation to individuals for having been put at risk is the topic of a study begun by George Heaton, a lawyer at the Center for Policy Alternatives. Professor Amadeo Odoni, Department of Aeronautics and Astronautics, began an examination of engineering economy in the presence of risk, uncertainty, and risk aversion; and Professor Jerome Rothenberg, Department of Economics, undertook to develop a model of how groups reach risk-related decisions. This work, which was funded under a grant from the Andrew W. Mellon Foundation, will help develop larger proposals for which funding will be sought. The ongoing research will continue to be vetted at the interdisciplinary faculty seminar on risk management. Professor Greenwood and Professor Alvin Drake, Department of Electrical Engineering and Computer Science, directed the overall effort.

Professors Greenwood and Daniel Metlay, Department of Political Science, began work on a closely related study, supported by the Russell Sage Foundation, examining the strategies various interested parties adopt to seek to influence the outcome of environmental, health, and safety regulatory procedures. They will be asking why certain strategies were selected, which appeared to "work," and how they affected the regulatory process.

Political development, long a Center concern, was the subject of several activities during the past year. Professor Lucian Pye, Department of Political Science, continued his analysis of responses to modernization in various Asian societies. Manuscripts of several chapters have been received and will be published in the coming year. The Rockefeller Brothers Fund supported his work. Under the guidance of Professor Myron Weiner, Department of Political Science, the Center continued to support the Joint Seminar on Political Development (JOSPOD), in cooperation with the Center for International Affairs, Harvard University. Plans were completed for a special JOSPOD program for the coming year, using its 25th anniversary year as an occasion to assess the political development field. Closely related to

the area of political development was the Center's continued close collaboration with Professor Nevin Scrimshaw, Department of Nutrition and Food Science, in matters relating to food and nutrition in developing countries. The Center also served as the MIT focus of a joint MIT-Harvard group concerned with problems relating to Women and International Development.

Science and technology policy continued as an area of Center policy. Many of the topics described here deal with aspects of that topic. In addition, Dr. Ann Hollick, formerly in the US Department of State and Johns Hopkins University, came to the Center under a program of the National Science Foundation aimed at increasing the visibility of women in science and engineering to work on issues in the planning of foreign policy involving science and technology.

The preceding paragraphs have cited a number of instances in which the Center has worked in collaboration with other centers, at MIT and elsewhere. Other examples over the past year include work on the Future of the Automobile Project, carried out by Professor Alan Altshuler, Departments of Political Science and Urban Studies and Planning, in collaboration with the Center for Transportation Studies, directed by Professor Daniel Roos. The Center's work on this project was supported by the US Department of Transportation. A second collaborative effort brought the Energy Laboratory and the Center together to study international energy policy matters, funded by an endowment established by the Japanese government. Those involved in work in this area included Professor Samuels and Dr. Thomas Neff, Director of International Policy Studies in the Energy Laboratory.

Closely related to this was a seminar organized for the Center by Professor Brian Smith, Department of Political Science, Dr. Charles Blitzer, Energy Laboratory, and Dr. Richard Lockwood, Department of Nutrition and Food Science, to focus on energy policy issues facing various Latin American governments. This series was funded by monies contributed to the Center for use as seed funds by the Exxon Educational Foundation.

As in previous years, the Center conducted an extensive program of seminars for the MIT community on subjects related to its research and international topics in general. In addition, special series were developed on arms control, south Asia, migration, risk management, energy policy in Latin America, and political development.

A number of visiting scholars enriched our program. Over the past year these included individuals from Bangladesh, Japan, Israel, the Philippines, the United Kingdom, and Germany, as well as American universities.

EUGENE B. SKOLNIKOFF

Center for Materials Research in Archaeology and Ethnology

The 1982-83 academic year was the sixth year of operation for the Center for Materials Research in Archaeology and Ethnology (CMRAE). Activities focused in three areas: graduate education of students from the six participating universities, doctoral research among students from both Center-affiliated and non-Center universities, and the offering of the second month-long Summer Institute course.

The Center offered a full-year graduate subject, Materials in Ancient Societies: Ceramics, to eight students from four of its member universities, making a total of 128 students - graduate students and senior undergraduates - who have enrolled in CMRAE subjects since the Center's founding. This year's offering was designed and taught by Suzanne De Atley, associate professor of Archaeology at MIT. Student research projects involved laboratory analysis of ceramic collections excavated by them (or provided by universities and museums), each project integrating an anthropological or art historical problem concerning ceramics with a consideration of the technological aspects of that problem. In addition, every student prepared ceramic thin sections of pottery for incorporation into the CMRAE standards and reference collection file of ceramic materials.

Three graduate students at the Center, one from Boston University, one from the University of California at Santa Barbara, and one from MIT, engaged in full-time research toward the doctoral degree. Of the two students supervised by Professor Heather Lechtman (MIT, Anthropology/Archaeology, and Materials Science and Engineering), one is studying the prehistoric development of copper metallurgy in west Mexico and its relation to Andean metallurgies, and the other is beginning an investigation into the pre-Columbian metallurgy of Ecuador. The latter student, who will receive her Ph.D. at MIT from the Department of Materials Science and Engineering, is that Department's first student to combine materials science and archaeology in the dissertation topic. The third student, supervised by Professor Suzanne De Atley (MIT, Anthropology/Archaeology), is concerned with the ceramic materials fundamental to ironsmelting technologies in east Africa during the iron age. All three carry out their laboratory analyses and experiments in the CMRAE Graduate Teaching Laboratory at MIT.

The Center established a Summer Institute in 1981-82, conceived as a mechanism through which scholars at non-Center institutions could benefit from the highly specialized and often unavailable education in laboratory-analytical skills in which the Center is expert. The aim is to provide individuals across the nation in such professions as anthropology, archaeology, the histories of science and art, and the conservation of archaeological and art objects with intense exposure to the theory and laboratory methods of the materials science of ancient and art historical materials. The Summer Institute format consists of a one-month intensive lecture and laboratory subject organized around a specific class of materials. The first course, Materials in Ancient Societies: Metals, was offered during June 1982. The second course, funded by a grant from the Alfred P. Sloan Foundation, was given in June 1983. Biological Material from Archaeological Sites: Fauna was taught by Richard H. Meadow of the Zooarchaeology Laboratory, Harvard University, and Hans-Peter Uerpmann of the Institut für Urgeschichte, Universität Tübingen. Professor De Atley serves as the administrative director of the Summer Institute.

A CMRAE committee chose 15 Summer Institute participants from a large pool of applicants. Six were graduate students, one a senior undergraduate, and eight were professionals - research professors in paleozoology, research specialists in laboratories devoted to faunal analysis, and museum curatorial assistants. Nine universities and three museums in the United States and Canada were represented by the Summer Institute participants as well as the Instituto Nacional de Antropología e Historia, Mexico. The course was an outstanding success and reflects an international interest in and need for the kinds of training the Center uniquely provides. The 1984 Summer Institute will treat the analysis of ceramic materials from archaeological contexts.

The Center continued its series of annual proseminars, six informal presentations during each academic year, enabling CMRAE faculty and graduate students to report on research in progress. This year scholars from Boston University, the University of California, Santa Barbara, the University of Cincinnati, Harvard University, and MIT discussed ongoing Center-related research.

HEATHER LECHTMAN

Committee on the Visual Arts

The Committee on the Visual Arts (CVA), composed of faculty, students, and administrators representing an Institute-wide constituency, met eight times during the 1982-83 academic year. Several meetings reviewed proposed acquisitions (gifts, purchases, and loans) to the MIT Permanent Collection (see Acquisitions below). Two subcommittees were formed and met in November and December to refine and reformulate the CVA policy and procedures on acquisitions for the Permanent Collection and Educational Programs.

The Permanent Collection subcommittee recommended acquiring works on paper for mini-galleries in public sites throughout the Institute; investigating the use of ILP funds for Permanent Collection acquisition; updating and expanding the existing Planning Office survey of available major public art sites to include indoor as well as outdoor locations; and developing new strategies, given dwindling one percent for art funds, for the continued acquisition of major works of paintings and sculpture.

The Education subcommittee recommended more frequently scheduled tours of the Collection, more didactic presentations of the working process of artists represented in the Collection, the offering of an Undergraduate Seminar in Contemporary Art, the production of videotapes documenting and explicating Hayden Gallery exhibitions, and increasing in-house publicity for CVA programs.

EXHIBITION PROGRAM

The 1982-83 season continued to demonstrate the CVA's commitment to acquainting both the MIT community and the larger New England audience with advanced and innovative work in painting, sculpture, photography, architecture, and design by both regional and nationally and internationally known artists.

The 12 exhibitions in the Hayden Gallery and the adjacent Hayden Corridor Gallery were all conceived, organized, and installed by the CVA staff. They drew an audience well in excess of 25,000, continuing the upward attendance trend of the past several years. Each exhibition opened with a public preview; many of the participating artists attended.

1982-83 Exhibition Schedule

Students Select, Hayden Corridor Gallery, August 27-September 26, 1982. Works on paper by local artists considered for acquisition by Student House through a CVA-sponsored contest to enhance a student living environment.

List and Stratton Student Loan Collection, Hayden Gallery, August 27-September 26, 1982.

Recent European Prints, Hayden Gallery, October 1-November 7, 1982. Nearly 80 prints presenting a wide view of contemporary graphics in Germany, Austria, Switzerland, Italy, England, and Holland (exhibition brochure published).

Local Visions II: The Beach, Hayden Corridor Gallery, October 1-November 14, 1982. A sequel to Local Visions: The Urban Environs, eight area photographers documented summer scenes at local ponds, lakes, and ocean beaches.

Mediums of Language, Hayden Gallery, November 19-December 23, 1982. Gallery installations by Vernon Fisher, Paul Sharits, and Myrel Chernick illustrated different symbiotic relationships between language and visual structures. Preliminary studies and other works on paper were hung in the Corridor (exhibition catalogue published).

James Turrell, Hayden Gallery, January 24-February 27, 1983. "Batten", a Space Division Construction conceived specifically for the MIT space played with the viewer's perceptual habits regarding space, color, and light.

Recent Selections: Desired Directions, Hayden Corridor Gallery, January 24-March 6, 1983. Works on paper which have recently come into the MIT Permanent Collection and others which the CVA would like to acquire.

Wakeby Day/Wakeby Night: Monumental Monotypes by Michael Mazur, Hayden Gallery, March 11-April 24, 1983. The two-part triptych purchased by the CVA for the dormitory at 500 Memorial Drive, with studies, versions, preliminary drawings (exhibition catalogue published).

Strange Stories: Marilyn Holsing and Judith Linhares, Hayden Corridor Gallery, March 11-May 1, 1983. Paintings on paper which refer to ancient myths, riddles, and rituals.

Affinities, Hayden Gallery, May 6-June 27, 1983. Paintings and drawings by two generations of artists (Terry Winters and Bill Jensen; Brice Marden and Myron Stout) who share a commitment to painting's traditional ambitions (exhibition catalogue published).

Self-Portraiture in Contemporary Photography, Hayden Corridor Gallery, May 6 - July 4, 1983. Nine leading photographers for whom the subject of self has been a major theme, representing a wide range of approaches to the medium.

ACQUISITIONS

The Permanent Collection was enlarged by gift and purchase. Among the additions were major portfolios of photographs by Berenice Abbott and Barbara Morgan; drawings by Alex Katz, Ellen Phelan, Gregory Amenoff, and Richard Smith; a sculpture by Auguste Rodin; 11 scale models and 43 working drawings for the MIT Chapel Bell Tower by Theodore Roszak. Ten works were added to the Student Loan Collection. (A complete list of 1982-83 acquisitions is appended.)

New Sitings, Installations, and Conservation

Niagara, a sculpture by Michael Steiner was sited in Compton Court, necessitating the re-installation of Ipousteguy's Cenotaphe near Building 66. 16 works on paper acquired with one percent for art funds were installed at 500 Memorial Drive; 12 Berenice Abbott photographs were hung in E-51 (Sloan School); numerous other works were sited throughout the Institute. Three paintings received treatment at the Fogg Art Museum Center for Conservation and Technical Studies.

EDUCATIONAL PROGRAMS

The CVA organized a wide range of educational activities intended to broaden awareness of an artist's historical context, working methods, and professional concerns, and to underscore parallel modes of artistic and scientific investigation. Gallery talks or panel discussions for the MIT community and the public were organized for each Hayden Gallery exhibition. A program of German videotapes and film was co-sponsored by the Committee and the Foreign Languages and Literature Section at MIT and the Goethe Institute, in conjunction with the exhibition "Recent European Prints." A half-hour videotape documentary was prepared for the exhibition "Michael Mazur: Wakeby Day/Wakeby Night" documenting the artist's working process in creating the MIT commission. The artist also gave a heavily attended lecture on his work. Gallery talks were also given to outside groups including the Boston Museum of Fine Arts Print Club. Tours of the art and architecture at MIT were given to several groups from MIT and from Boston area organizations. Artfacts, an informal group open to the entire MIT community, visited museums and galleries in the Boston area and held discussions with curators and other professionals.

Artist-in-Residency

James Turrell was artist-in-residence in Hayden Gallery during the January IAP period. While Turrell constructed an installation, the gallery was opened periodically to allow the MIT community and the general public to observe the changing sense of material and space central to Turrell's work and to speak directly with the artist about his work.

Artist Project

Antonio Muntadas, a fellow at the MIT Center for Advanced Visual Studies, and artist Peter D'Agostino were asked to organize an artists' project which explored the interrelationship of art, advertising, and technology. Muntadas and D'Agostino produced a 100-page illustrated book entitled The Un/necessary Image, with individual contributions from 19 other artists. The book is being distributed by Tanam Press, New York.

Publications and Public Information

Art and Architecture at MIT: A Walking Tour of the Campus was published in December and was so enthusiastically received that the first printing has been exhausted. A second printing is currently in production. Three exhibition catalogues and one exhibition brochure were produced. Catalogue sales and distribution nationally and internationally continued the expansion of the previous year. CVA-sponsored activities were reviewed in both the general and art press in Boston and nationally. The collaboration between architects and artists for the new Arts and Media Technology Facility has received wide attention, nationally and internationally.

Proposal Preparation and Outside Support

Three exhibitions and projects were supported by the National Endowment for the Arts; other support came fom the MIT Council for the Arts and a private benefactor.

CVA STAFF
BORIS MAGASANIK

Educational Video Resources

Educational Video Resources (EVR) is a video consulting group for the Institute. Hundreds of faculty, students, and staff come to us each year for advice on the uses of video in teaching, research, coursework, documentation, artistic creation, and performance. Many are already skilled professionals in video; most have some idea of their needs and require consultation on the nature of their own enterprise as video extends, transforms, and distributes it.

In education our facilities are used in the teaching program of the Film/Video Section, by graduate students in the Master of Arts in Visual Studies, and by students doing projects in other courses. Film study courses bring us classic movies on tape for cablecast on the MIT system. In several large classes the teaching staff provide examination review sessions on cable. Introductory Physics produces a one-hour program weekly to help students with problem sets. One third of students polled view this program every week and more than 80 percent sometime during the semester. They vote for its continuation by a ratio of more than 20 to one. Occasionally we provide large-screen video projection with computer interface and live video interaction between remote locations at the Institute.

In research we have increased the number of productions that describe MIT activities for specialist and general audiences. Some groups use our equipment to document their own research. We are becoming a major producer of such material ourselves, and now have more requests for productions than we can accommodate. Electrical Engineering and Computer Science created a video archive of their research as part of their centennial celebration. The Research Program on Communications Policy is doing extensive video archiving of panel discussions among pioneers in the development of computers in our studios. Several research groups are using video as a research tool itself.

For the community we continue to document and cablecast significant events, such as a Sloan School conference on "Effective Business Management: A Japanese Perspective," live coverage of the teach-in "Solutions to the Arms Race," and the MIT Commencement, as well as programming for the Community Service Fund, Safety Office, Campus Patrol, Alumni Office, and Women's Independent Living Group. We do a lively business advising individuals, groups, and departments about what equipment they should buy. Our maintenance shop offers its services to any Institute group. Our staff can help anyone wanting to understand how telecommunications developments affect their professional lives.

The MIT Cable System has been notably active this year. It has been extended into and within many buildings, and a major effort is under way to cable dormitories. The number of educational channels has been increased from three to four and the number of commercial channels on the system from eight to nine. We are installing interconnections that will allow us to broadcast MIT seminars to Lincoln Laboratories, and examining how to use them to reach fraternities across the river and industrial facilities in the greater Boston area.

Following the advice of an Institute Advisory Committee for EVR, we have reduced our routine service functions. For example, the self-study courses produced by the Center for Advanced Engineering Study are now videotaped and duplicated outside of the Institute.

EDWIN F. TAYLOR

Facilities Use

The Office of the Provost continues to formulate and implement policy for the use of Institute facilities by recognized MIT groups. The special assistant to the Provost, Louis Menand III, is aided in these efforts by a committee composed of Stephen D. Immerman, assistant dean for Student Affairs; Ronald Suduiko, special assistant in the Office of the Chairman of the Corporation; Mary Morrissey, director of the Information Center; Gayle M. Fitzgerald, assistant for special events; Winston E. Flynn, assistant registrar; and John Kowtko and James Ellard of the Student Center Committee. This committee generally meets weekly to review requests for the use of facilities.

Although use of MIT facilities is in part governed by the Institute's tax-exempt status, facilities use should contribute to the enhancement of purposes for which the Institute has been chartered, with primary focus on its educational and research roles. MIT facilities may not be used directly to support candidates for public office or for lobbying for particular legislative issues, nor may the Institute's facilities by used to support profit-making organizations. The presentation by undergraduates of talks by candidates for public office is considered to be educational in nature, and therefore provision is made for the appearance of candidates for a variety of public offices.

The domain over which the committee presides includes all of the academic space at the Institute, the Julius A. Stratton Student Center, departmental memorial rooms, and the like. Inevitably this office and the facilities committee are drawn into broader issues involving controversial and difficult potential use of MIT facilities. As a consequence, the Office of the Provost is frequently consulted on a wide range of political, social, and even religious issues stemming from facilities use. For example, the appropriateness of activities suggested for IAP in January of each year is reviewed by the special assistant to the Provost who frequently consults the committee as well as other appropriate offices within the Institute.

During 1982-83, in addition to a number of smaller meetings, the Institute was host to, among others: The International Federation of the Organic Agriculture Movements Conference; The American Libraries Association Collection Management and Development Institute Meeting; The Noise Control Engineering Conference (NOISE-CON 83); The Physicians for Social Responsibility Meeting; The Conference on Photovoltaics; The Tenth International Optical Computing Conference; The Fifth Conference on the Physics of the Jovian and Saturnian Magnetospheres; and the Meeting of the Society for Industrial and Applied Mathematics.

LOUIS MENAND III

EDUCATIONAL PROGRAMS

The Biomedical Sciences Curriculum

The Curriculum Committee, chaired by Professors Walter H. Abelmann and Herman N. Eisen, conducted the regular periodic reviews of HST subjects. This year particular attention was paid to the sequence and coherence of the offerings in the neurosciences. These reviews have proved highly effective in enhancing the quality of the HST curriculum.

A Thesis Committee, chaired by Professor Samuel Latt, was appointed in order to improve the selection of thesis topics and the supervision of the work and writing of the required theses.

A task force on the integration of the physical sciences and engineering into the HST curriculum was chaired by Professor George Benedek. Particular attention was paid to the subjects of Quantitative Physiology; Cardiovascular, Respiratory and Renal Pathophysiology; and the Human Nervous System. The recommendations of this task force led to the moving of the Respiratory and Renal courses from the third to the second semester so that better coordination of these courses with Cardiovascular Pathophysiology would occur.

The research seminars, organized and run by HST M.D. candidates, proved again successful and of very high quality. These seminars feature presentations by HST students who are engaged in research either for a companion higher degree or in fulfillment of the requirements for the HST thesis.

HST students continue to excel. They represent more than half of all the M.D.-Ph.D. candidates at Harvard Medical School and, in June 1983, they received somewhat more than half of the honors in a special field awarded at graduation. Their qualifications and qualities are recognized too in the outstanding internships and residency appointments which they receive.

Medical Engineering and Medical Physics Curriculum

With the matriculation of the first year class in September 1982, the Medical Engineering/Medical Physics Program (MEMP) reached a state of maturity. The Program now enrolls nearly 50 students distributed over the five years of the curriculum. In June 1983 the Program graduated four students, and a fifth is scheduled to complete his studies in the summer of 1983. Of the seven students who have graduated to date, most have decided to continue their education either as postdoctoral fellows or as candidates for the M.D. degree.

As MEMP students have developed interest in pursuing formal studies leading to the M.D. degree, the HST Division has negotiated agreements with Harvard Medical School and the Tufts University School of Medicine for admission to advanced standing of students in the MEMP curriculum. These agreements permit a select group of students to matriculate in these medical schools after completion of their studies for the doctorate in medical engineering or medical physics.

MEMP students are distinguishing themselves academically and professionally. Joanne Donovan, a student in the final stages of her Ph.D. research and a candidate for the M.D. degree, received the first prize of the American Society of Gastroenterology for a paper describing her research conducted under the supervision of Dr. Martin C. Carey and Professor George Benedek.

The MEMP Program continues to contribute actively to undergraduate education through its participation in the Undergraduate Research Opportunities Program (UROP). The HST Division affords UROP students the opportunity to engage in biomedical research with faculty members not only at MIT but also in the Harvard Teaching Hospitals. To facilitate these activities, a new subject, HST 598, has been established to provide opportunities for undergraduates to receive letter grades for their research experiences within the Division.

At the graduate level a new subject HST 599 has been established to provide opportunities for independent study and research by graduate students not registered in the Division. This subject provides Harvard Medical School students access to MIT faculty and MIT students access to the faculty of Harvard Medical School. Subject HST 582 Biomedical Signal Processing has been thoroughly revised and expanded to include significant laboratory experience. Visiting Assistant Professor Dan R. Adam of the Technion in Israel contributed greatly to the development of this subject. HST 583 Biomedical Microelectronics was offered this spring for the first time by Professor David J. Edell. This offering provides hands-on

experience in the design, fabrication, and testing of microcircuitry for implantation in animals. The circuits, which are wired directly to nerve endings, can be used for control of prostheses or can be used to short-circuit spinal cord injury sites. Professor Alan C. Nelson and Dr. James C. Weaver in collaboration with Dr. Herbert Hechtman and Dr. Frederick Schoen have developed HST 210 Innovation in Medicine, an offering that provides students with instruction in the process of innovation and with experience in the application of this knowledge to the solution of real problems that occur in medical practice.

Construction of the facilities of the Department of Biomedical Engineering at the Massachusetts General hospital has been completed, and the professional staff has been restructured to meet the objectives of that department as defined in an agreement between the hospital, the HST Division, and Harvard Medical School. The development of this department awaits the appointment of the Taplin Professor of Biomedical Engineering who will hold a primary appointment in the HST Division. With the development of this department at the Massachusetts General Hospital, a study group of Harvard and MIT faculty members was charged with the evaluation of the desirability and need for a similar department to be established in the Longwood Medical area. The conclusion of this study group was that the engineering needs of the various institutions in this area were being met effectively and that for the present there was no need to establish a similar department.

FACULTY

Dr. Lee Gehrke was appointed Lecturer in Anatomy for one year after which he will serve as Assistant Professor of Anatomy in the HST Division and in the Department of Anatomy of Harvard Medical School. Professor Richard J. Cohen was promoted to Associate Professor with his primary appointment in the HST Division and a secondary appointment in the Department of Physics at MIT. Professor Alan C. Nelson was appointed the William Keck Assistant Professor of Biomedical Engineering, with his primary appointment in the Department of Nuclear Engineering and his secondary appointment shifted from the HST Division to Whitaker College. Professor Dan R. Adam of the Technion in Israel, who has served as Visiting Assistant Professor in the HST Division for the past two years, has left MIT to return to Israel. Professor Stan N. Finkelstein of the Sloan School of Management was appointed the Kieckhefer Associate Professor of Technology Assessment in the MEMP Program.

The M.D. Admissions Committee, which is chaired by Professor William S. Beck, includes senior and junior faculty members from Harvard Medical School and MIT as well as members of the HST student body. This year's committee was exceptionally well balanced and its deliberations were unusually efficient. There was a total of 356 applicants for the 25 positions in the class. The quality and achievement of the applicants are outstanding. A matter of concern, however, is the increasing cost of medical education with the resultant impact on disadvantaged students or those from modest economic circumstances.

HST RESEARCH ACTIVITIES

Research and development activities in HST were described in detail in the annual report of 1982, and the reader is referred to that report for a fuller description. These research activities comprise the Biomedical Engineering Center for Clinical Instrumentation directed by Professor Roger G. Mark, the Harvard-MIT Rehabilitation Engineering Center directed by Dr. William Berenberg with Professor Robert W. Mann as Associate Director, and the Center for Health Effects of Fossil Fuels Utilization directed by Professor Gerald N. Wogan. In addition there are multidisciplinary research programs on the Optimization of Dose Distribution in Cancer Radiation Therapy under the direction of Dr. Bengt Bjarngard, the Thromboresistant Materials Program led by Dr. Edwin W. Salzman and Professors Edward W. Merrill and David F. Waugh, the program in Short-Lived Radiopharmaceuticals for the Diagnosis and Treatment of Disease under the direction of Dr. S. James Adelstein and Professor Gordon L. Brownell, the program in Tumor Hyperthermia under the direction of Dr. Padmakar P. Lele, and a program for the evaluation of equipment for hyperthermic treatment of cancer, also directed by Professor Lele. In addition there are many individual research projects of faculty members operating under the auspices of the HST Division. Altogether, the research and development activity of HST faculty and staff engage 87 research members of the two universities. The research and development activities of HST now constitute an annual research budget of approximately $7 million.

During the past year in an effort to stimulate research programs in which laser technology is applied to problems in clinical medicine, a workshop on "Lasers in Experimental and Clinical Medicine" was organized and administered by Dr. Irving A. Berstein, Assistant Director of the HST Division, and Professor Ernest G. Cravalho, Associate Director of HST. The program was comprehensive and included presentations by MIT and Harvard Medical School faculty members on laser technology in a wide range of clinical problems and on opportunities for further applications of such technology in various areas of clinical medicine. Following this workshop, smaller meetings of interested faculty members are being held in an attempt to initiate new collaborative research projects which promise to be productive.

Professor Cravalho and Dr. Berstein are also organizing a symposium on "Frontiers in Medical Technology" to be held at MIT on October 5-7, 1983. The symposium is sponsored jointly by the HST Division and the Industrial Liaison Office of MIT. Thirty-three faculty members of MIT and Harvard Medical School will present papers in fields such as drug metabolism and drug delivery systems, prosthetics, surgery, and new diagnostic and therapeutic techniques.

RESOURCE DEVELOPMENT

During the past year Dr. Walter L. Koltun, Assistant Director for Resource Development in the HST Division, has succeeded in raising approximately $900,000 of which $355,000 was raised for endowment and $554,200 for operating expenses including student aid and support of faculty, educational, and research activities. Since July 1970, approximately $53.4 million has been raised for educational research programs: $10.02 million for endowment, $4.74 million for expendables and facilities, and $38.65 million for research and development.

IRVING M. LONDON

Whitaker College of Health Sciences, Technology, and Management

A new doctoral program in Health Policy and Management was reviewed and approved by the Committee on Graduate School Policy and by the Faculty of MIT. The formulation of policy governing the allocation and management of resources in health care delivery systems poses challenging issues to which this new academic program is addressed. It has been developed to educate physicians in these policy and management issues. This program is supported primarily by a grant from the Henry J. Kaiser Family Foundation. It is administered and led by Professor Edward B. Roberts of the Sloan School of Management, Professor Stan N. Finkelstein also of the Sloan School and the Harvard-MIT Division, Professors Jeffrey E. Harris and Peter Temin of the Department of Economics, and Professor Harvey M. Sapolsky of the Department of Political Science. The first class of students will matriculate in September 1983.

A second new academic program for which financial support is now being sought is in the field of pharmaco-engineering and applied pharmacology. As new developments in biotechnology make new drugs available in increasing numbers, means must be sought to provide for the effective and economical delivery of valuable and expensive therapeutic agents in the treatment of patients. This new program is being developed in an effort to solve various problems that face the medical community and the pharmaceutical industry. This program offers no new degree but rather makes use of existing doctoral degrees in the Departments of Chemical Engineering, Chemistry, and Nutrition and Food Science. It is organized around a core of advanced subjects developed and taught by faculty members working in these fields and it will provide research opportunities for students in chemistry, chemical engineering and biotechnology who have a special interest in the mechanism of drug action and drug delivery. The program is headed by Professor Robert S. Langer of the Department of Nutrition and Food Science, the HST Division, and Whitaker College. He has been joined in this effort by Professor Christopher T. Walsh of the Department of Chemistry, Professor William M. Deen of the Department of Chemical Engineering, and Professors Alan R. North and Michael A. Marletta of the Department of Nutrition and Food Science. The program is intended to provide education at the predoctoral and postdoctorals level and will admit students once appropriate funding has been achieved.

The computer facility under the direction of Dr. William A. Gilbert has expanded with the construction of a computer terminal room which includes not only terminals but also graphics, plotting and printing hard-ware, and provides 24-hour access to the computing resources of Whitaker College. These resources now include a new data base suitable for application in DNA sequencing. The addition of new software systems and the expansion of the hardware resources have greatly amplified the capability of the computer facility.

In the electron microscope laboratory under the direction of Professor Alan C. Nelson, progress was made toward the development of automated image processing. During the coming year, this laboratory should be able to provide the full range of services to system users. Professor Nelson was named the William Keck Assistant Professor of Biomedical Engineering this year.

In recognition of his work in the field of pharmacoengineering and applied pharmacology, Professor Langer has been appointed the first Dorothy Poitras Associate Professor of Biochemical Engineering.

Dr. Monty Krieger, Assistant Professor in Whitaker College and in the Department of Biology, is engaged in the study of receptor-mediated endocytosis with particular reference to the operation of this mechanism in the metabolism of lipoproteins and their relationship to the development of atherosclerosis.

Professor Robert D. Rosenberg of Whitaker College and the Department of Biology is continuing his studies on the elucidation of molecular interactions which regulate the blood coagulation system and maintain the normal function of endothelial and smooth muscle cells in the wall of blood vessels.

Dr. Irving M. London, Professor of Medicine at Harvard Medical School and Professor of Biology at MIT, is pursuing his studies on the elucidation of the mechanisms controlling the synthesis of hemoglobin, the definition of the role of heme in regulating the synthesis of globin and other proteins in normal and abnormal eukaryotic cells, and the definition of the principal determinants of erythroid cell differen-tiation and maturation.

In October 1982, Dr. London, Director of Whitaker College, announced his intent to leave the directorship at the end of the academic year in June 1983. During the first five years in the history of the College, 1978-1983, academic programs and administrative structure were defined, more than $26 million was raised for the construction of the Whitaker College building and for initial endowment, and the recruitment of new faculty members was begun. With this initial phase completed, Dr. London is resuming the directorship of the Harvard-MIT Division of Health Sciences and Technology on a full-time basis. Professor Emilio Bizzi, Eugene McDermott Professor in the Brain Sciences and Human Behavior, has been named as Director of Whitaker College beginning July 1, 1983.

Independent Activities Period

Beginning on January 3, Independent Activities Period (IAP) this year got off to an earlier start than ever before in its twelve-year history. Many students, however, overcame the aftermath of their New Year's celebrations and made it back to campus for the first day of IAP '83.

Guide Activities

During the ensuing three and one-half weeks (January 3-26), 615 different activities were offered by MIT volunteers. Typical of the varied programs sponsored by an academic department were the 15 activities in Materials Science and Engineering. In addition to a series of faculty lectures introducing the field, the department offered laboratory sessions and seminars on technical subjects such as welding processes, rapid solidification, electron microscope calibration, and composite materials. On the lighter side were "In Vino Veritas," wine-tasting sessions led by a faculty member, and "Fudged Results: Fudge Making Made Less Hard," a student-led workshop.

The other 600 activities offered throughout the Institute were just as varied. People could make quilts, hammers, valentines, furniture, dulcimers, and even microcomputer systems. Those interested in electronics had three different workshops from which to choose. Other workshop topics were clogging, Japanese linguistics, bicycle repair, analytical electron microscopy, magic, computer text processing, and assertiveness training.

Faculty involvement in IAP activities continued to increase gradually, with 26 percent of the faculty having their names listed in the *IAP '83 Final Guide*. Ten academic departments presented series of introductory lectures by their faculty. Civil Engineering offered a series on computers and civil engineering; each morning presentation by a faculty member was followed by an afternoon session in which students could use computers. As always, individual faculty members put together imaginative programs. An associate professor in Earth and Planetary Sciences invited people to reconstruct the last ice age; he gave an introductory lecture and then after the next snowstorm led participants in making, in Killian Court, a model of glacial North America. In Aeronautics and Astronautics, three faculty members began a project to design and construct an orbital launch vehicle. In addition to the popular intensive Spanish I and German I courses, faculty in Foreign Languages and Literatures offered such activities as a two-day total immersion in French, production of a play in Spanish, a Russian sing-along, and a dramatic reading of a German comedy.

Organizing an IAP activity takes time, energy, and imagination. Yet each year hundreds of volunteers make the effort. Why do they do it? Because they are satisfied with the response from the community at large and find the experience rewarding. Of the 492 activity organizers responding to this year's annual questionnaire from the IAP Policy Committee, 80 percent reported that participation equaled or surpassed their expectations, and 88 percent said that their activities were worthwile.

All the IAP activities are described in the IAP Guides, newspaper-like catalogs. This year's Guides and other IAP publications featured the drawings of children who had attended the MIT Day Camp the previous summer.

Student Questionnaire

While it is evident that many people continue to organize and participate in Guide activities, these activities represent only the visible side of IAP. Because students are free during IAP to pursue their own interests on or off campus, it is always difficult to measure and report on students' use of IAP. This year the IAP Policy Committee asked students to complete a questionnaire about what they did during IAP. The Policy Committee is extremely grateful to the Registrar's Office, departmental undergraduate and graduate offices, and the advisors who distributed these questionnaires on registration day for second semester. Thanks to their help, the return rate for the questionnaire was quite high: 35 percent among undergraduates and 20 percent among graduate students.

Students specified how much time they spent at MIT and away from MIT in various endeavors, for example, work, academic work, nonacademic activities, Guide activities, and recreation. The IAP Policy Committee plans to continue gathering similar data for the next few years so that responses can be compared over time. This spring, the Committee informally shared preliminary data from the first survey with the Committee on Educational Policy.

As part of the questionnaire, students were asked to rate their IAPs on a scale from 1 (poor) to 5 (excellent). The average rating from undergraduates was 4.04, and from graduate students, 3.87. Students were also encouraged to make written comments about the general concept of IAP or their particular experiences. These comments were overwhelmingly positive. Many students wrote long paragraphs detailing all they did during IAP. Others kept their messages short: "IAP is great!" "Don't mess with IAP."

Committees and Staff

The 1982-83 IAP Policy Committee was chaired by Professor Shaoul Ezekiel. Members included: Professor Edward B. Allen; Professor Catherine V. Chvany; Professor Charles L. Cooney; Mary Z. Enterline; Professor Kenneth Hale; Dr. Merton J. Kahne; Professor Henry W. Kendall; Professor Harvey F. Lodish; Dr. Louis Menand III; Professor Edward W. Merrill; Professor David Michael; Winston Mok, Class of 1983; Professor Cardinal Warde; Rebecca Waring, graduate student; and Professor David Gordon Wilson.

Margaret S. Richardson chaired the IAP Administrative Committee, which is made up of staff and student volunteers from various departments and administrative groups. Members were Steven Barber, Class of 1984; Deirdre Dow-Chase; Andrew Eisenmann; Ms. Enterline; Kristin Foss, Class of 1983; Mary Jasinski; Steven Gass; George R. Kendall; Dr. Menand; Michael Schlein, Class of 1984; Clifford Truesdell; and Maryglenn Vincens.

Dr. Menand, special assistant to the Provost, led the IAP Planning Committee, which is composed of departmental coordinators. Continuing as IAP staff were Ms. Enterline, manager; Ms. Vincens, staff writer/editor; and Mr. Kendall, senior office assistant.

MARY Z. ENTERLINE

Joint Program in Oceanography and Oceanographic Engineering

This past year, Professor John Sclater, Director of MIT's Joint Program with the Woods Hole Oceanographic Institution (WHOI), announced that he will be leaving the Institute. Professor Sclater has accepted an endowed chair as Professor of Geophysics at the University of Texas at Austin; his appointment there will begin September 1, 1983. As of this date, no new director has been named. However, Mary Athanis will continue on as Administrator of the program.

In 1982-83, 14 students were graduated from the MIT/WHOI Joint Program in Oceanography and Oceanographic Engineering. Of these, 13 received the doctoral degree, and one received the Engineer's degree.

Currently, there are 88 students enrolled in the Joint Program, split almost evenly among the five disciplines, with Biological and Physical Oceanography having 20 students each, Oceanographic Engineering having 19, Marine Geology and Geophysics having 15, and Chemical Oceanography having 14.

The Joint Program received 143 applications for the 1983-84 academic year; of these, 32 were admitted into the program. This year, our applicants' acceptance rate was extremely high: 78 percent of those admitted have either started the program this June or will begin it in September. In addition, one of our chemical oceanography applicants was awarded an Ida Green Fellowship for 1983-84, marking the fourth year in a row in which a Joint Program woman has been named an Ida Green Fellow.

MARY ATHANIS

Libraries

Events in the MIT Libraries of the past year were substantially overshadowed by the necessity for a major review of staffing and activities in order to cope with a significant budget reduction in FY1984. The goal of this effort was to accommodate a cut of five percent in the salary and wage budget as well as to cover continuing inflation in the cost of library materials and services. The principal effects of the budgetary review were the elimination of 10 positions, the curtailment of hours of access of public service units, the elimination or reduction of some activities and services, and several internal administrative and organizational changes. The exhausting and sometimes painful process of the review was not, however, without positive aspects and potential benefits. Through a temporary freeze on filling vacancies, the Libraries were able to accomplish all the necessary staff reductions without instituting a single layoff. The Institute reiterated its commitment to maintaining quality research collections by providing additional funds for acquisitions to offset about half of the costs of inflation in library materials. Some of the procedural and organizational changes emanating from the budget review will improve the effectiveness and efficiency of the library system. During the year, the staff provided suggestions for cost saving that were put into immediate effect and that have already produced beneficial results.

The principal changes that resulted from the budget reduction include (1) the elimination of the reserve function in the Student Center Library; (2) decentralization of binding preparation; (3) elimination of subject cataloguing of MIT theses, MIT reports, and periodicals; (4) reduced service in the Microform Center in Hayden Library and in the Chemistry Reading Room; and (5) decentralization of student staff administration. In addition, the Libraries will give up responsibility for administration and maintenance of the Von Hippel Reading Room, effective July 1, 1983. Responsibility for this room has been taken over temporarily by the Center for Materials Science and Engineering (CMSE); CMSE may continue to operate the facility at a reduced level.

In order to identify which operations would be curtailed or eliminated it was determined whether the collections or services were duplicated elsewhere within the system (Student Center Library reserves and Von Hippel Reading Room), and efforts were directed to eliminate entire functions rather than attempt to maintain the current level of service with a reduced staff. Of major concern throughout the budget process was the desire to maintain the present strength of the Libraries' collections.

As part of the development of the Libraries' FY1984 budget, it was determined that, in order to maintain a satisfactory level of acquisition and service, as well as to introduce new services, it would be necessary to increase certain fees and charges. Effective July 1, 1983, quick copy photocopy charges will be increased from $.05 to $.10 per page; fines for overdue materials will be increased from $.10 to $.25 per day; and fees charged to non-MIT borrowers will also increase substantially. During the year, the Academic Council also approved an increase in the thesis processing fee to take effect in September, 1983.

In the year ahead, at least as much effort as was expended in the reallocation of resources and reassignment of staff will have to be spent in the implementation of the decisions that were made. While it is inevitable that users and staff of the MIT Libraries will continue to feel the impact of a reduced operating budget, the Libraries must continue to monitor, evaluate, and when necessary, change policies and procedures to respond to the priorities of the system and the continuing goal of maintaining the quality of and access to collections in order to provide services appropriate to the research and educational needs of the Institute.

In addition to the extensive review of the budget described above, the Libraries continued working on other major projects during the year. The Request for Proposal for an automated circulation system was submitted to five vendors and, late in the year, a decision was made to award the contract to Geac Computers International, Inc. One of the major attractions of this system is its potential as an integrated library system that would include the functions of an online catalogue, acquisitions, and serials control as well as circulation. Many members of the staff, along with representatives of Information Processing Services and the Purchasing Office, participated in the evaluation of the proposals. As the academic year concluded, the Libraries began to accelerate activities associated with the implementation of the circulation system including the appointment of a project manager, the establishment of task forces, and the development of an implementation schedule.

Another important project was the investigation and evaluation of options for the use of microcomputing equipment and word processing software in the Libraries. A Task Force on Microcomputers, under the leadership of the administrative officer, devoted a substantial amount of time and effort looking at available systems and equipment and potential applications. An initial installation of eight or nine units is expected within the next few months; additional systems will be installed during FY1985.

As one of the 11 member institutions of the Boston Library Consortium (BLC), the MIT Libraries participated in two projects with the potential for significant benefit for the Libraries and their users. The BLC Serials Review Project undertook a comprehensive review of periodical subscription duplication in the Consortium. Because of the high cost of subscriptions, the field of science was selected as the pilot test area for this program. A Consortium committee, chaired by the MIT Director of Libraries, reviewed all current duplicate science subscriptions and selected several as candidates for possible cancellation by member libraries. Selection was made on the basis of the number of current subscriptions, the relevance of the titles to teaching and research programs, the importance of the title as reflected by inclusion in abstracting and indexing services and by frequency of citation, and, in some cases, on use studies. Decisions to cancel will be made individually by each library but will be reviewed by the committee prior to actual implementation. The second Consortium project was a joint venture with the F.W. Faxon Company to develop an online union list of serials to be available through Faxon. With financial support by the BLC, Faxon, and the Commonwealth of Massachusetts with Library Services and Construction Act (LSCA) funding, this project is seen as a prototype for other library consortia and cooperatives throughout the country. From a local perspective, the system has the advantage of combining the heretofore separate BLC and MIT serial lists into a single file as well as providing the ability to add, update, and, ultimately, access serial records online.

At the beginning of the second quarter of the year, the Libraries began work on a Title II-C grant funded by the U.S. Office of Education. This project has three main components: the entering into the OCLC data base of records of materials in the area of science, technology, and society, many of which were not previously included in that file; the organization of a number of manuscript collections in the same general subject area; and the preservation of books, manuscripts, and photographs in the MIT Libraries that represent unique resources and that require microfilming, photocopying, or restoration. The Libraries have received an award from the Office of Education for a second year of this project at a somewhat reduced level, particularly in the area of cataloguing.

The public services units of the library system completed a year of change and uncertainty. The staffs of the divisional and branch libraries continued to provide a high level of service despite cutbacks in student staffing and hours of access required to balance to FY1983 budget. Based on a long-term commitment to the use of data base searching as a component of regular reference service, and on a successful year-long experiment in the Science Library, a decision was made to extend the service to all divisional libraries and two branches (Aeronautics and Astronautics, and Earth and Planetary Sciences). A major effort that will extend into the coming year involves a detailed examination of library services to non-MIT users and of means to alleviate pressures on staffs, facilities, and collections evolving from use by a continually increasing group of students, scholars, and industrial researchers. The challenge is to find ways to limit the use of the Libraries' resources by those outside MIT without denying access to unique and specialized resources that the Libraries are committed to make available to the scholarly community.

Several important developments occurred in collection development and management, in preservation, and in technical services--acquisitions and cataloguing. Major activities in collections included planning for the use of a new title announcement service as part of materials selection that will significantly reduce the amount of time involved in the acquisitions process. Following the evaluation of programs offered by various vendors, a decision was made to adopt this system in all divisional and branch libraries early in FY1984. The Libraries served as host to a Regional Collection Management and Development Institute in October, 1982, sponsored jointly with the American Library Association's Resources and Technical Services Division and the Boston Library Consortium. This conference brought together more than 120 librarians from throughout the country for a series of presentations and discussions of new techniques in collection management.

In the area of cataloguing, a principal development was a substantial increase in productivity in all categories of materials processing. Especially noteworthy was a 10 percent increase in monographic and music cataloguing and a 51 percent increase in new serial title cataloguing. Overall production in the Catalogue Department was up 38 percent. The Department successfully incorporated a management team as part of departmental administration and also integrated the Title II-C cataloguing operation into its regular activities.

Three noteworthy events took place in preservation: the completion of a brittle book survey with particular emphasis on older engineering journals; the establishment of a Boston Library Consortium Preservation Committee; and, perhaps of most immediate importance, the establishment, as part of the Libraries regular budget, of a preservation fund, an endowed fund having as its base the previous Friends of the Library Fund with additions to the principal being made from gifts and from the sale of duplicate materials.

A major effort in the area of acquisitions was made under the aegis of the Joint Committee on Technical Processing. A subgroup on acquisitions undertook an analysis of the entire acquisitions function in the Libraries and issued recommendations, the implementation of which produced significant changes in the pre-order searching process.

Activities in the Institute Archives and Special Collections focused on sponsored projects. In January, two staff members were added to begin work on the Andrew W. Mellon Foundation-supported program on the appraisal of scientific records. Two additional staff members were hired for the manuscript portion of the Title II-C project described above. The Institute Archivist continued to work half-time on a project supported by the National Science Foundation devoted to the appraisal of scientific and technical records. Other major projects involved organization and processing of the papers of the Neurosciences Research Foundation, F.O. Schmitt, and Howard W. Johnson, retiring Chairman of the MIT Corporation. The Records Management Program continued to expand: seven new disposition schedules were completed and eight are in progress. Three large-scale programs are under way involving student records, fiscal records, and the files of the School of Engineering.

Among the exhibits of the MIT Museum and Historical Collections during the year, the most noteworthy were the 100th Anniversary of the Department of Electrical Engineering; Math in 3D (geometric constructions by Morton Bradley); Nathaniel G. Herreshoff--The Engineering Wizard of Bristol (ship, yacht, and steam engine design); and a commemorative exhibit honoring the late William Baker, Curator of the Hart Nautical Collections.

In the Aga Khan Program, the principal developments included the designation of a Coordinator of Library Programs; a continuation of acquisition, cataloguing, and outreach activities; testing of the Building Activities Data Base; and accelerated progress on a thesaurus for the Visual Images Data Base and on the development of a videodisk storage system to complement that file.

The panoply of activities sponsored by the Libraries during the 1983 Independent Activities Period included a concert series and presentations on thesis preparation; film images of the professions; video developments; personal computers; library automation; quilting; needlework; exploring cultural myths; care and handling of photographs, prints, and letters; career information; new developments in the humanities; horticultural hints; neighborhood documentation; the history of biology at MIT; and occult sciences.

Highlights of 1982-83 in the area of administration and personnel included:

- --the publication of the Librarian Staff Handbook.
- --a series of programs presented by the Institute Personal Assistance Program for the library administration, Library Council, and supervisors explaining the purpose of this service and the referral process involved.
- --a Management Skills Institute for 30 members of the librarian and support staffs presented by the Office of Management Studies of the Association of Research Libraries.
- --continued development of a mission and objectives statement for the Libraries.
- --establishment of a Performance Evaluation Task Force to work on the scheduling of librarian and support staff evaluations and on the forms used in this process.
- --a series of seminars sponsored by the Staff Development Committee on running meetings, managing time, and taking minutes.

Two long-awaited interior renovations took place during the year. One was the reorganization of space on the fourth floor of the Barker Engineering Library to provide more efficient staff offices and work space; public service areas formerly in that space were moved to the fifth floor. The other was the installation of much-needed shelving in the former seminar room in the Music Library. Work progressed on the preparation of building N57 as the permanent home of the Resource Sharing Center and the move to that building was scheduled for July of 1983. The new sign system was installed in the Humanities and Science Libraries. During the April meeting of the Corporation Visiting Committee for the Libraries, considerable discussion was devoted to the whole area of space, facilities, and the long-term preservation of the collections. In response to a recommendation from the Committee, the Libraries will, during the next year, develop a long-range plan for the renovation and upgrading of physical facilities for ultimate presentation to the Institute administration.

As in past years, the Libraries continued to benefit from the generosity of many individuals and organizations who contributed materials and funds. Among the major gifts received during the past year were a collection of marketing research materials from Harfax Data Base Publishers; Frost and Sullivan reports donated by Stanley Klein; a collection of philosophy, literature, and Judaica from Herman Pollack; and a large collection of musical scores, recordings, and books from the estate of the late Morton Loewenthal. Major additions to the manuscript and archival collections were received from Howard W. Johnson, the Neurosciences Research Foundation, F.O. Schmitt, the family of the late Jule Charney, Albert G. Hill, and the Union of Concerned Scientists.

A complete list of individual donors to the Libraries for 1982-83 appears in the published version of this report. This publication also includes a statistical abstract, a compilation of staff activities, and a record of personnel appointments, promotions, and resignations and is available upon request from the Office of the Director of Libraries.

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The Libraries note with appreciation the long service of Francis Ludington of the Microreproduction Laboratory, who retired on June 30, 1983, after 29 years of service.

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In the year ahead, the Libraries will have many challenges to confront including implementation of budget reductions and the reallocation of resources, planning for installation of the automated circulation system, planning for development of an online catalogue, development of policies and procedures for the substantially enlarged Resource Sharing Center, development of policies for service to non-MIT users, planning for the renovation and upgrading of physical facilities, a major review of bibliographic instruction, as well as a whole host of other projects. All of this must be accomplished in the context of continuing to operate and improve a complex system of interdependent departments and services. As the year just completed has shown, however, the capability to deal with difficult problems does exist. The past year was an extremely trying time for the entire library staff. Their response to the uncertainties of the budget and to the need for extensive planning and investigation in many other areas was extremely gratifying. Although monetary and physical resources are indispensable to the operation of a research library, human resources are the most valuable. In the end it is the dedication, ingenuity, and perseverance of the staff of the MIT Libraries that has made and will continue to make the difference. The staff members of the MIT Libraries have earned the appreciation of the Institute community, of the scholarly world in general, and especially of the Libraries' administration.

JAY K. LUCKER

Lowell Institute School

The Lowell Institute School (LIS) was established at MIT in 1903 to provide evening instruction in technical subjects for residents of the Boston area. Today the School continues this tradition by offering subjects in the areas of modern technology which are not readily available at other evening institutions. Entry-level courses require an adequate high school preparation, and the more advanced instruction is geared to the practicing technician who has an associate degree or equivalent experience.

The programs of study range from single subjects designed to broaden job skill levels to comprehensive study of new technological areas in preparation for employment in a new field. There is a strong emphasis on practical aspects and development of careful experimental technique combined with sufficient theory to provide an adequate foundation of understanding. Certificates are awarded to those who satisfactorily complete a course. In addition, students who complete a program of courses may earn a Certificate in Drafting Technology or a Certificate in Electronics Technology.

During 1982-83, LIS offered 32 evening courses in the fall term and 33 in the spring term. The fields of instruction included analog and digital electronics including microprocessors through advanced applications; mechanical, electrical, and architectural drafting; printed circuit board design; blueprint reading; machine tools including numerical control; metal joining; welding/fabricating; scientific glassblowing; building maintenance; creative photography; effective speaking; and computer programming. New courses were introduced in advanced microcomputer laboratory, basic woodworking, first-level management, and advanced printed circuit board design. In addition, refresher courses were offered in mathematics to support both the drafting and electronics curricula.

LIS continued to offer intensive one-week daytime courses for individuals working in industry. An introductory digital electronics course was conducted on campus for CBS Television Network technicians, and an advanced microcomputer course was taught off campus at Bell Telephone Laboratories in North Andover.

LIS admitted a total of 1,362 students to its courses in 1982-83, 1,327 to the evening classes and 35 to the intensive daytime courses. Of those who enrolled, 77 percent successfully completed the certificate requirements. Among those who completed courses were 63 MIT employees and four regular MIT students. Fifteen students earned the Certificate in Drafting Technology, and nine students earned the Certificate in Electronics Technology.

The past academic year has seen LIS expand its program of unique evening courses which no other Boston-area school can match. The high percentage of students who successfully complete their courses indicates that both the subjects offered and the level of instruction are well matched to their needs.

BRUCE D. WEDLOCK

Mining and Minerals Resources Research Institute

The Mining and Mineral Resources Research Institute (MMRRI) has utilized the resources available to it to continue to support and encourage new initiatives at MIT in research and teaching activities that are related to mineral resources. Funds available this year have supported a total of nine graduate students in the Departments of Civil Engineering, Mechanical Engineering, Materials Science and Engineering, and Earth and Planetary Sciences. Support of Professor Terry Ring in the area of mineral engineering was continued throughout the year, and funds were allocated for the purchase of several important items of equipment for the VAX 11/730 computer that was purchased recently by the group in Process/Chemical Metallurgy.

A program of research that is directed to the development of innovative methods in underground mining is being developed jointly between faculty members in the Department of Mining Engineering at The Pennsylvania State University and Professor Peterson's group in the Department of Mechanical Engineering. Professor Peterson has had this program in progress with industrial support for several years. The participation by people at Penn State helps to broaden the scope of the program to include aspects of mining that are not covered at MIT.

This year the Bureau of Mines has established a Generic Center for the study of problems related to respirable dusts in the mining industry. The participating institutions are The Pennsylvania State University, the University of West Virginia, the University of Minnesota, and the Massachusetts Institute of Technology. Our part of the program is to be a study of the nature of the fine particulates that constitute the respirable dusts in metal mining operations. Professor Ring and Mr. John McCarthy, Research Scientist in the Energy Laboratory, are co-principal investigators for the MIT segment of the Generic Center.

The program of research on the nature of flow of gases and solids in the recirculating fluidized bed was completed in the spring. The work included a study of the heat transfer from the bed to a cylindrical sensor in the flowing stream of gases and solids.

Professor Elliott, Director of the MMRRI of MIT, was named Membre d'Honneur of the Société Française Metallurgie and Honorary Member of the American Institute of Mining, Metallurgical, and Petroleum Engineers this year. He was also elected Fellow of the American Institute of Chemical Engineers.

JOHN F. ELLIOTT

Northeast Radio Observatory Corporation
Haystack Observatory

The Northeast Radio Observatory Corporation (NEROC) is a consortium of 12 institutions* formed in 1967 to promote radio and radar astronomy research and facilities in the northeastern United States. NEROC receives financial support for its principal facility, MIT's Haystack Observatory, from the National Science Foundation (NSF), and project support from NSF, the National Aeronautics and Space Administration (NASA), the National Geodetic Survey (NGS), and the other Federal agencies, and it uses the administrative services of MIT in the conduct of its business. Observing proposals submitted by prospective users are considered by a review committee on the basis of scientific merit and suitability of the available instrumentation.

The main instrument at the Observatory, located at Westford, MA, is a 120-foot diameter paraboloidal antenna enclosed in a radome. It is heavily used by the astronomy community as a radio telescope with radiometers operating at 18-, 13-, 6-, 3.8-, 2.8-, 2-, 1.35-, and 0.7-cm wavelength. The Haystack telescope constitutes an important astronomical resource, particularly in the wavelength region 1.5-0.7 cm, which lies between the shortest wavelengths covered by most of the larger telescopes and the longest wavelengths at which the smaller, true millimeter-wave instruments are most profitably used. At 0.7 cm, the telescope has a beamwidth smaller than the 1-arc-minute resolution of the human eye.

In the past year, the telescope was used by approximately 75 investigators from over 20 different institutions, and 45 articles were published in scientific journals based upon this work. Approximately 14 percent of the telescope usage was by MIT faculty and their students. The low-noise, high-frequency receivers and the wideband, high-resolution digital correlation spectrometer are crucial to these operations. In particular, a low-noise maser amplifier receiver at a frequency of 43 GHz (0.7cm wavelength) built by the Haystack receiver group was used in an attempt to detect silicon nitride (SiN) in interstellar gas clouds. This receiver also was used to study the v=1, J=1.0 transition of SiO in regions of young star formation.

The dense cores of dark clouds, possibly the sites of future star formation, and regions of ionized gas (HII regions) were studied using transitions of the HC_5N molecule and the inversion transitions of the NH_3 molecule. These NH_3 transitions, which are closely spaced in frequency, require widely differing conditions for excitation, allowing molecular cloud parameters such as temperature and density, as well as dynamical information, to be obtained. Anomalies in the amplitudes of the hyperfine lines of the NH_3 molecule were also studied in galactic gas clouds. From these studies the state of excitation of the gas cloud could be assessed. Other programs have included studies of the properties of interstellar masers at 43 GHz (SiO) and 22 GHz (H_2O). An attempt was made to detect 22 GHz H_2O masers, which are usually associated with regions of star formation, in galaxies showing recent bursts of star formation.

Very long baseline interferometer (VLBI) research and development continued as a leading in-house activity at Haystack. The VLBI technique involves simultaneous observations of the same object with widely separated radio telescopes; the records made, using identical, special VLBI recording systems for these observations, are subsequently brought together in a correlation processor to yield interferometer fringes. For astrometry and studies of complex source structure, VLBI provides resolution not attainable by any other means. Haystack is a member of the VLBI network of seven observatories, which makes astronomical VLBI observations every two months, and has developed a new recorder and processor (MK III) which yields a fivefold improvement in sensitivity over older ones. The network uses the Mark III VLBI system and the Mark III processor at Haystack for high sensitivity measurements, thereby extending fundamental research to fainter and more distant objects.

The high angular resolution afforded by VLBI allows the study of motion in the central regions of many radio sources. The apparent internal motions are often faster than light or "superluminal," and may indicate that plasma is being ejected from a central core with speeds approaching that of light. Further studies of the "superluminal" phenomenon in radio jets, which was first discovered in the quasar 3C 279

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*Boston University, Brandeis University, Brown University, Dartmouth College, Harvard University, MIT, Polytechnic Institute of New York, Harvard-Smithsonian Astrophysical Observatory, State University of New York at Stony Brook, University of Massachusetts, University of New Hampshire, and Yale University.

from VLBI observations between Haystack and the 64-meter telescope at Goldstone, CA, promise to reveal the true nature of the energy sources at the center of radio galaxies. VLBI studies using MK III show that most normal galaxies, including our own, have intensely bright radio emission at their centers. Recent improvements in the MK III VLBI processor at Haystack have included the efficient processing of pulsar and spectral line data. Phase reference VLBI techniques, in which a nearby calibration source is used as a reference, have further improved the sensitivity of VLBI. This technique has been used to great advantage in the study of the gravitational images of the quasar 0957+56. It has also been used to make maps of the pair of quasars 1038+528 A and B at several wavelengths. If motion occurs in 1038+528 A or B, it should be possible to verify that the motion takes place in the jet extending from the core, while the core itself remains stationary.

Haystack Observatory is involved in the study of a new generation of VLBI instrumentation needed for the Very Long Baseline Array. (The VLBA is under consideration by the NSF as a major new start in Astronomy. The current proposal is for a 10-element VLBI array of 25 meter telescopes covering the continental USA, Hawaii and Puerto Rico.) Haystack is presently working on a tape recording density enhancement for the Mark III with NASA support. A further development of this system is being considered for the VLBA.

With support from NASA, VLBI is being used to make precise geodetic measurements between Haystack, the 40-meter telescope at Owens Valley Radio Observatory, CA, the 26-meter telescope of the Harvard College Radio Observatory in Fort Davis, TX, the 100-meter telescope of the Max Planck Institut in Bonn, Germany, and the 20- and 25-meter telescopes of the Chalmers Institute of Technology in Onsala, Sweden. The measurements, which are part of the NASA Crustal Dynamics Project, have established that the drift rate across the North American tectonic plate (Haystack-Owens Valley) is less than 1 cm/year, and they are expected to establish a precise drift rate between the North American and European plates in a few years. This network has recently been augmented by adding another station in California (Mojave site within the Goldstone complex) and several transportable stations. These new sites are being used to measure details of the crustal motions in the Western United States in the hope that an understanding of motions and strain accumulation will aid in the forecasting of earthquakes. Additional VLBI sites in Italy, Germany, and Spain are expected to be included in geodetic measurements of global tectonic plate motions.

The 60-foot diameter Westford antenna, located one mile south of the 120-foot telescope, was operated as a dedicated VLBI station for the National Geodetic Survey (NGS). The POLARIS (Polar Analysis by Interferometric Surveying) Project measures changes in the absolute rotation rate of the earth by measuring UT1, and the changing point of intersection of the earth's axis and the crust, or polar motion. Along with a station at Ft. Davis, these parameters are measured on a weekly basis to an r.m.s. accuracy of about 0.3 msec in UT1 and 15 cm in the X-component of polar motion. Beginning in September, 1983, measurements will be made every 5 days to support the international MERIT campaign of intercomparison of techniques for measuring Earth rotation. The addition of a third site at Richmond, FL (now nearly completed), will permit measurement of the Y-component of polar motion as well. The Westford antenna, equipped with standard NASA receivers at 2.2 and 8.4 GHz, also participates regularly in the NASA Crustal Dynamics Project observations of continental and intercontinental baselines. It has been shown that VLBI measurements of UT1 and polar motion are an order of magnitude more accurate than other techniques, and are not subject to the vagaries of weather as are satellite-laser and classical optical methods. These quantities are of practical importance in timekeeping, surveying, and navigation, as well as being of fundamental interest to earth science.

On 30 April 1983, Dr. John V. Evans, Director of the Observatory, resigned to assume the position of Director of Research, COMSAT Corporation.

RICHARD P. INGALLS

Office of Minority Education

INTRODUCTION

During the 1982-83 academic year, the Office of Minority Education (OME) underwent several changes which will hopefully improve the quality, direction, and effectiveness of its programs. Its primary mission, however, has not changed -- combatting attrition and acting as an academic support structure which responds to the needs of minority students, promoting academic, professional, and personal success.

A major change in the Office this year was the addition of a full-time director, Dr. William D. McLaurin. Ms. Deborah Alexander served as Special Assistant to the Director, and Ms. Karen Fulbright provided part-time consultant services. Ms. Alma Melendez, an intern from the Harvard Graduate School of Education, represented the first Hispanic individual who has worked on the OME staff. The Office continued to receive services from Ms. Pearline Miller, the Assistant Director, and Ms. Gloria Payne, Administrative Assistant. Ms. Mireille Desrosiers very capably provided secretarial services to OME, and the Office has profited from the work of several student staff members.

This year, we sought to increase communication with all of our students. This was accomplished through a variety of methods, including an "open door" policy, meetings with minority organizations, interviews with the students themselves, and attendance at conferences at which students and educators shared strategies for concomitantly achieving academic excellence and other educational goals.

The OME will be able to fulfill its charge of ensuring the academic success of minority undergraduates at MIT as long as we continue to constantly evaluate all of the services and then tailor those services to meet the needs of the students we serve. There is a myriad of variables that can impact upon the academic performance of MIT minority undergraduates. OME will try to identify these variables, and then attempt to control them in such a way as to positively influence the growth and development of minority students.

The Office focuses primarily on the areas of pre-college programs (Project Interphase and the MITE Program), early identification of academic problems (Freshman Watch), and academic support services (tutorials, counseling, and mini-courses). These initiatives will be continued, and in some cases, expanded (i.e., Sophomore Watch). In the future, OME shall become more actively involved in financial aid, career counseling, alumni relations, and the recruitment of minority students, faculty, and staff. Theoretically, OME should be flexible enough to address any problem which might, now or in the future, hinder the academic success of minority undergraduates at the Institute.

PRE-COLLEGE PROGRAMS

Project Interphase

Project Interphase is an intensive seven-week academic program. There were 42 participants in the 1982 program. As in past years, students received academic preparation in chemistry, humanities, mathematics, physics, and computer programming. A formal introduction to the resources of the Institute and to general academic skills, group athletics, and social activities were delivered to both students and staff. Student evaluations and a 15-page survey questionnaire were among some of the tools used to provide feedback to determine program effectiveness.

The 1983 version of Project Interphase will include a counseling component and a few curriculum changes, including a chemistry component that combines material in 5.40 General Chemistry and 3.091 Introduction to Solid-State Chemistry, a humanities section that will satisfy phase one of MIT's new writing requirement, a physics course that will include corridor labs, and expanded computer programming course. The 1983 program will have 38 participants.

Minority Introduction to Engineering

The 1983 Minority Introduction to Engineering (MITE) Program will be operating from OME for the first time this year. We are proud to be involved with and to administer this successful MIT program which was coordinated by Dr. Ernest Cravalho for the past eight years. Dr. Cravalho will continue as academic coordinator. The target group of this program is minority high school students who have successfully completed their junior year. The program is designed to expose talented minority students to careers in engineering while simultaneously addressing the national problems of urban education and the underrepresentation of minorities in engineering.

This year's students were, for the first time, recruited nationally. 44 students were admitted to the program; over 280 applications were received. Selection criteria included: high academic achievement, as evidenced by the high school transcript; membership in a minority group; PSAT scores; strong recommendations from math/science teachers; an interview with a member of the MIT Educational Council, and the completed application. The program is divided into three main areas: academic, design, and professional presentations. The academic component consists of pre-calculus, mechanics (physics), English and computer programming. Competitive design contests and design labs together with formal presentations round out the MITE curriculum.

EARLY IDENTIFICATION

Freshman Watch

With the cooperation of faculty and staff who teach freshman core requirement subjects, freshmen have been asked, as needed, to come into OME for academic counseling and tutorial services. This program supplements the activities of the freshman advisor, and communication with each freshman advisor is maintained. During the 1982-83 academic year, OME staff received information on students earlier in the semester, which enabled staff to point out various alternatives to students in academic jeopardy which might not exist for them later in the semester. This program has been so useful to students that an expanded version is planned for future years.

ACADEMIC SUPPORT SERVICES

Black Students Union Tutorial Program

The goal and objectives of the Black Students Union (BSU) Tutorial Program remain the same -- to provide free, high quality tutorial assistance which will enhance the students' ability to meet the academic challenge of MIT. Though our target group is minority undergraduates, all MIT students are welcome to avail themselves of the services offered by the BSU Tutorial Program. This past year free tutorial assistance was delivered in over 60 science and engineering courses. The staff of the tutorial program is composed of MIT undergraduate and graduate students. The student coordinators this year were Patrick Gerdes, Brenda Kitchen, Damion Wicker, and Xavier Marshall.

In order to improve student utilization and communication, a fall semester dinner, which was attended by 250 undergraduates, was held. In addition, a general information brochure on the Tutorial Program detailing tutors' schedules and telephone numbers was distributed to the students both semesters. During the fall semester, the total number of Tutorial Program visits was 700. This figure, however, does not include the visits that students made to tutors outside of the tutorial room. The number of Tutorial Program visits in the spring semester was 512. The total number of out-of-office Tutorial Program visits for the spring semester was approximately 40. Total hours logged in the BSU Tutorial Program for the academic year was 3,724.

SSAS Program

Strategies and Secrets for Academic Success (SSAS) is a unique seminar series designed to promote academic excellence and professional achievement among undergraduate students. By informing students of the educational opportunities, supports, and resources within the MIT community and the strategies for utilizing them, students can better plan and implement the strategy that works best for them. Approximately 300 students participated in this year's SSAS sessions. The interaction between Institute faculty, administrators, role models from the private sector, and students provided a forum for dynamic discussions. The SSAS seminars were coordinated by Fred Allen, Raymond Samuel, Richard Williamson, Dennis Ward, and Chiquita White.

The Freshman Buddy System

This program, coordinated by Arlene Roane, Luis Torres, and John Hammond, was able to combine 33 upperclassmen and 75 freshmen in the fall semester. The spring semester saw 43 upperclassmen offering their support and expertise to 84 freshmen on a wide variety of academic and nonacademic concerns.

Multics Text Editing Seminars

This is a new program which was added in the fall of 1982. Developed to address a need which exists especially among students who have a great deal of writing to do for their courses, the aim of the seminar is to enable the participants to produce papers, lab reports, and other documents with the aid of a Multics word processor. Each seminar consisted of one to two hours with two students and the seminar leader. Bernard Loyd, the seminar leader, reported that although the seminars were introduced very late in the term, the response was very positive. By the first week in December, approximately 25 students had registered for the seminars.

ACTIVITIES

OME either fully or partially sponsored a wide variety of minority student-related activities during 1982-83. Working mainly in concert with the Black Students Union, La Union Chicana por Aztlan, and the Association of Puerto Rican Students, OME provided support for leadership conferences, programs, lectures, advertisements, seminars, and other cultural events. In addition, an OME Open House was held on October 29, 1982.

OME sponsored three seminars during the 1983 IAP. The first was a seminar on problem solving, the second dealt with preparation for the Medical College Admission Test (MCAT), and the third was a communications workshop. During the 1984 IAP, OME in conjunction with the Physics Department will offer a concentrated study course in 8.01 Physics 1. This course is designed to present additional options and allow for better pacing of academic work.

AWARDS

OME selected Karl Reid to receive the Monsanto Award as the third-year engineering student with the best academic record. OME also presented academic awards to the male and female minority students who achieved the highest academic records. In 1982-83 these award recipients were Lisa Washington and Juan Carlos Mercier. A distinguished administrator award was presented to Dr. Ernest Cravalho for his outstanding service to the minority community.

W. D. MCLAURIN

Operations Research Center

The Operations Research Center (ORC) was established in 1953 to provide educational and research opportunities for students and faculty interested in the interdisciplinary field of operations research. The academic staff of the ORC is drawn from many departments, including the Sloan School of Management, Electrical Engineering and Computer Science, Urban Studies and Planning, Aeronautics and Astronautics, Civil Engineering, Mechanical Engineering, Ocean Engineering, Mathematics, and Physics. The ORC is managed by two codirectors, Professors Richard C. Larson and Jeremy F. Shapiro, and a core of administrative staff. Approximately 30 graduate students are enrolled in the master's and doctoral degree programs, and 20 faculty and a number of visiting scientists are affiliated with the Center.

Faculty and students at the ORC were engaged in a broad range of activities during the past year. Research was directed at numerous topics in applied industrial operations research, network optimization, public sector applications, energy planning, and mathematical programming. In this report, we discuss briefly each of these areas and provide information about the Center's educational programs.

RESEARCH ACTIVITIES

Applied Industrial Operations Research

During the past year, ORC faculty and students developed new analytic methods and decision models for a wide variety of operational, tactical, and strategic business planning problems. At the operational level, there were studies of production/inventory planning and control systems focusing on optimal policies for multi-echelon inventory systems, job shop scheduling, and the Japanese Kaban or "just-in-time" scheduling system. Tactical planning problems were addressed in research on new approximation methods for optimally determining stocking levels of spare parts for a computer manufacturer and in the completion of an annual requirements planning system for a consumer products company. The latter system, based on mathematical programming models, can be used to develop operating budgets for manufacturing facilities, as well as to study capacity expansion and major supply decisions.

On the strategic planning level, two efforts aimed at developing new models and analytic methods were begun by ORC faculty and graduate students. A theoretical foundation was developed for studying how firms should defend their markets against new competitive entrants with price, product formulation, advertising, and distributional strategies. New mathematical programming models were developed and tested for identifying optimal capacity expansion plans when there are learning effects. These models, which are appropriate for high-technology companies, capture the paybacks to early periods in a product life cycle from capacity expansion plans that permit accelerated learning.

Network Optimization

Under National Science Foundation funding, ORC faculty and students studied a variety of basic research problems in network analysis and optimization. Included were network design problems, large-scale Euclidean location problems, traffic equilibrium, and a general linear activity equilibrium model. Other fundamental research in this area involved facility location selection with the L_1 metric in the presence of barriers to travel. In another project, ORC faculty were involved in studying distribution planning for freight carriers, considering such issues as vehicle routing and scheduling, commodity routing and scheduling, customer-route-distribution center assignments, and distribution center capacity planning. In research sponsored by the Office of Naval Research, research began on developing new solution procedures for solving emergency scheduling problems. The methodologies included interactive scheduling and hierarchical decomposition techniques.

Public Sector Applications

Operations research applications in the public sector were developed by ORC faculty and students in the areas of criminal justice, urban services, and health systems. Under a grant from the National Institute of Justice, research was performed on the development of mathematical models for analyzing the use of prison space. Probabilistic models were developed and tested which measure arrest risks that are age-dependent and experience-related.

Research continued in the area of urban service systems. Much of this work was directed at methods for determining optimal locations of facilities on a transportation network, in which the total operating system is stochastic in nature. Additional research was performed on the analysis of transportation problems with inhomogeneities in the travel medium; these can include barriers to travel (such as parks, cemeteries, areas of a harborway) and high-speed travel links (such as interstate highways). Mathematical

procedures were further developed for routing vehicles in a "dial-a-ride" system having many locations for customers with many different destinations.

ORC faculty participated in research in the design and operation of mental health care systems. The major accomplishment of this research has been the development of a conceptual framework for resource planning in a community-based mental health care system. Planning exercises based on this research will be undertaken with mental health agencies in four states.

Energy Planning

Work continued during the past year in the application of operations research models and methods to energy planning problems. ORC faculty were involved in a project to design and implement a national energy planning system for Argentina. This system is based on a mathematical programming model that selects primary fuel exploration and development strategies, along with energy transportation and transformation activities, to meet forecasted energy demands over a 20-year period at minimal total discounted cost. Research continued in the use of statistical and data analysis methods for the exploration and development of natural gas resources.

Modeling research for electric utility planning was also undertaken. New models were developed for electric load management by consumers facing a variable price of electricity. A project was begun to construct new models to evaluate the uncertainties in the long-range planning options of utilities committed to coal-burning plants.

Mathematical Programming

A wide variety of investigations into the mathematical structure of optimization problems and methods for their solution was undertaken. New results were obtained characterizing polynomial-time aggregation of integer programming problems. Work continued on new algorithmic methods for the "matroid parity" problem; this problem is an elegant generalization of several important problems in combinatorial optimization. Research also continued in the study of dynamic periodic systems with application to a range of scheduling problems.

Research in the application of abelian group theoretic methods to integer programming was completed. Topics addressed in doctoral theses included the computational complexity of group optimization problems, numerical methods for controlling the size of groups derived from integer programming problems, and penalty methods based on group optimizations. Research was begun on the extension of mathematical programming duality to mixed integer programming problems.

Several research efforts were directed at the application of aggregation, approximation, and decomposition methods to large and difficult mathematical programming problems. Research sponsored by the National Science Foundation was conducted on new parametric methods for mixed integer programming based on dual methods and the principle of inverse optimization. An integration was effected between network aggregation methods and resource-directed decomposition approaches for facilities location problems. These same decomposition methods were specialized for a variety of network design problems. Approximation methods were derived for optimizing dynamic lot size and stochastic production problems.

New research, funded by the Electric Power Research Institute, was begun on the application of stochastic programming with recourse models to long-range planning problems. These models produce strategies which hedge against the major uncertainties faced by the decision maker. A major goal of the research is to develop efficient solution methods, based on decomposition approaches, for dealing with the escalating size of these models.

EDUCATIONAL PROGRAMS AND ACTIVITIES

The Operations Research Center offers two interdepartmental graduate degree programs--one leading to a Master's Degree in Operations Research and the second leading to a Ph.D. Enrollment in these programs is through direct admission to the Interdepartmental Program in Operations Research and through interdepartmental registration of graduate students who are admitted to other MIT departments. Each year about five Ph.D. and 10 S.M. candidates are admitted to the programs. In any given year, there are approximately 30 graduate students enrolled in the programs. During the 1982-83 academic year, there were six master's degree candidates and 20 Ph.D. candidates in the programs. Five Ph.D. and four S.M. degrees were granted in 1982-83.

Ph.D. candidates qualify for the doctoral degree program by passing a series of comprehensive examinations (the Qualifying and General Examinations), normally taken during the second year of graduate study. During the past several years, there has been a tendency for graduate students to bypass the formal master's degree program and work on their Ph.D. degrees once they have qualified. In order to compensate for the declining number of master's degree candidates that has resulted from this trend, a larger number of S.M. students will be admitted to the fall 1983 entering class.

In addition to the regular degree programs, the Operations Research Center also sponsored three courses offered through the 1982 Summer Session program. Resource Management: A New Approach to Corporate Planning was offered to a group of businessmen from Taiwan. The program employed the special services of an interpreter and transliteration equipment to aid the non-English-speaking participants. Two one-week courses, Decision Analysis: Basic Concepts and Applications, and Decision Analysis with Multiple Objectives: Concepts and Applications, were also presented.

The Operations Research Center Seminar Series was organized in 1982-83 by three doctoral student coordinators. A total of 25 seminars was presented during the regular academic session, as well as a number of special seminars offered during MIT's Independent Activities Period. Among the distinguished visitors who made presentations in this series, we were fortunate to have George B. Dantzig, Professor of Operations Research at Stanford University, and Harold Kuhn, Professor of Mathematics at Princeton University.

The Philip M. Morse Reading Room

This year, the Operations Research Center renamed its reading room the Philip M. Morse Reading Room, in recognition of the contributions of Professor Morse, who was founder and initial director of the OR Center in 1953. Among his numerous accomplishments, he is recognized as the founder of the field of operations research. The students and faculty of the OR Center gathered at a reception to dedicate the reading room in his honor.

RICHARD C. LARSON
JEREMY F. SHAPIRO

Project STILE

Project STILE (Student-Teacher Interactive Learning Environment), drawing from the experience of its staff with the MIT/Wellesley Upward Bound Program and based on Robert Rosenthal's pioneering research on the self-fulfilling prophecy, is an in-service human development program for teachers, parents, and students. The Project was founded in 1977 by MIT staff and Cambridge public school teachers, parents, and students under the auspices of the Massachusetts Department of Education Title IV-C funding for innovative programs. The major premise of the Project is that school performance can be dramatically improved by helping teachers develop skills to create more interactive classroom environments for their students and by looking to parents and the community as educational resources.

The classroom approach is based on an observation and feedback system which helps teachers to effectively communicate high expectations for all their students. Parents, trained in STILE techniques, assist in the process by observing and providing teachers with feedback. Students are trained as participant observers in the classroom and use this unique position as an opportunity to provide feedback to teachers. The optimum objective is an ongoing, three-way interaction among teachers, parents, and students.

Project STILE was validated as an exemplary educational program by the Massachusetts Department of Education in 1979 and has been disseminated to a number of Massachusetts communities including Belmont, Chelmsford, Dorchester, Hamilton/Wenham, Nantucket, and Somerville. During this past year, the Project began work with tutors in the Education Division of the Massachusetts Department of Corrections, the Boston School Improvement Program, and Arlington Cable T.V. which videotaped a three-session parent workshop.

JOHN P. TERRY

ROTC Programs

National and local interest in programs of the Reserve Officer Training Corps (ROTC) continued to grow during the past year. The national resurgence of interest in ROTC was reported frequently in the news media, and was reflected at MIT through increased enrollments and levels of activity. Total enrollment in the three services at MIT increased by 15 percent over the previous year's level with 31 more MIT students and 38 more cross-enrolled students participating. The Navy and Air Force units showed substantial growth over the previous year, while the Army unit again experienced a decline.

All three services benefited from the participation of students at several local universities through cross-enrollment arrangements. Such students accounted for 28 percent of the participants in MIT's ROTC programs (Army, 43%; Navy, 29%; Air Force, 23%). Their presence helps to maintain the units at viable levels and adds to their intellectual diversity. However, concern was expressed during the past year that MIT, as host institution, provides all of the necessary services for participation by cross-enrolled students but receives no support from their home institutions. In response to that concern, a review of past and present cross-enrollment arrangements was initiated near the end of the past year and will be a topic of continuing review in the coming year.

Enrollment in the three ROTC programs at MIT in the fall of 1982 was as follows:

YEAR	I	II	III	IV	TOTALS
SERVICE					
Army	22	18	20	21	81*
Navy	77	54	25	19	175**
Air Force	93	96	48	26	263***
TOTALS	192	168	93	66	519

* Includes 35 students cross-enrolled from Harvard University (16), Tufts University (14), and Wellesley College (5).

** Includes 50 students cross-enrolled from Boston University (25), Harvard University (20), Tufts University (3), and Wellesley College (2).

*** Includes 61 students cross-enrolled from Harvard University (26), Northeastern University (1), Tufts University (28), and Wellesley College (6).

Sixty seniors received commissions during the year. Of those, fifty were awarded on May 26 in a tri-service commissioning ceremony at the USS Constitution National Historical Site. Guest speaker on that occasion was Lieutenant General Kenneth L. Peek, Jr., Deputy Chief of Staff, Manpower and Personnel, Headquarters, United States Air Force.

The ROTC Faculty Advisory Committee, under the chairmanship of Professor David K. Roylance, continued its active review of the ROTC program and evaluation of prospective ROTC instructors. Professor Roylance participated in a four-day indoctrination and familiarization cruise with Navy ROTC cadets on board the USS MILLER (FF 1091) out of Newport, Rhode Island. Professor Frank E. Perkins, Associate Provost, spent two days for similar purposes at the Army ROTC Advanced Camp at Fort Bragg, North Carolina.

The three detachment commanders--Colonel George S. Smith, Jr. (Army); Captain David V. Burke, Jr. (Navy); and Colonel Joel S. Hetland (Air Force)--each completed their second year of service at MIT. Colonel Smith was transferred at the end of the year to Hanscom Air Force Base where he assumed direction of the Army's research, development, and production efforts on a new surveillance target attack radar system.

FRANK E. PERKINS

Sea Grant College Program

Congress established the National Sea Grant Program in 1966 to facilitate the economic development and prudent management of ocean and Great Lake resources. The Program is based on the Land Grant College concept of integrating university research, education, and public outreach. MIT was asked to join a Sea Grant network of academic institutions in 1968. In 1976, in recognition of the Institute's contribution to the national ocean effort, it became the first private university to become a Sea Grant College.

The director of Sea Grant at MIT is Chryssostomos Chryssostomidis, professor in the Department of Ocean Engineering. Professor Chryssostomidis, who assumed the directorship in July, 1982, divides his duties between academic and research responsibilities in the Department and management of Sea Grant. He is assisted by Norman Doelling, executive officer, and Lawrence W. McKinnon, administrative officer. Keith D. Stolzenbach, associate professor in the Department of Civil Engineering, and Anthony J. Sinskey, professor in the Department of Nutrition and Food Science, serve as associate directors of research coordination. E.R. Pariser, senior lecturer in the Department of Nutrition and Food Science, is associate director of education. Sea Grant's advisory services are led by Arthur B. Clifton, Elizabeth T. Harding, and Mr. Doelling. A State-Industry Council and the Sea Grant Committee of faculty representatives from all departments with marine research interests help the Program define long-term research plans and select current proposals.

This past year, MIT received a grant from the National Oceanic and Atmospheric Administration for $1,700,000. In addition, the Program raised $1,443,513 in matching funds, exceeding the one-third requirement of Sea Grant's federal charter. In addition, MIT Sea Grant administered $268,900 in pass-through funds for marine research. Thirty-two faculty, 26 graduate students, and eight undergraduate students from seven departments or centers participated in Sea Grant projects. Those included Civil Engineering, Computer Science and Electrical Engineering, Materials Science and Engineering, Mechanical Engineering, Ocean Engineering, Nutrition and Food Science, and the Center for Policy Alternatives.

RESEARCH

Sea Grant's research is responsive to the identified needs of the marine community. At present the Program, calling upon the Institute's science and engineering strengths, is concentrating on five major research areas: Unmanned Underwater Work Vehicles, Offshore Facilities, Coastal Processes, Living Resource Utilization, and Technology for Ocean Uses.

By the end of this decade, the need for offshore oil, gas, and minerals is expected to accelerate dramatically. Accordingly, Sea Grant has made a research commitment to develop technologies that will make deep-sea operations economical, safe, and environmentally sound. Faculty and students have made significant strides in developing new instrumentation and analytic techniques for evaluating offshore soil characteristics accurately and economically. Platform design that accounts for severe hydrodynamic loads has been, and continues to be, of major importance in MIT Sea Grant's research plans. Projects for the immediate future include research on the mechanics of mooring cable systems, riser response to wave excitation, wave breaking forces, and wind-generated wave current and forecasts in waters of finite depth.

MIT, which initiated the nation's first department of naval architecture, continues to contribute research for the maritime industries, in part through the Sea Grant Program. Design criteria are being developed for vessels that will be operating in the ice-infested Arctic. A concept for achieving greater propulsor efficiencies through the forward placement of an auxiliary propellor garnered an award of excellence from the National Sea Grant Association for the undergraduate student who undertook the study. Researchers are seeking to adapt existing turbine technology that could lead to fuel savings for fishing vessels and harbor work boats, and a multidisciplinary project is looking for a way to prevent rope deterioration, a cause of many serious maritime accidents.

Robots are expected to have many uses for exploration, salvage, construction, and maintenance tasks in deep-sea conditions. With Sea Grant support, research is under way to develop innovative components and systems, using advanced theories and techniques to improve performance in remotely controlled unmanned work vehicles and to develop communications systems that eliminate the need for cumbersome tethers for relaying data from seabed to surface.

Coastal waters offer a different kind of research challenge than the offshore environment. Studies of ecosystems are necessary for making intelligent decisions that govern commonly owned resources. A new computational scheme has been developed that will help coastal zone planners find generic solutions for improving the circulation in small, enclosed areas. MIT faculty and students have also developed effective instrumentation for measuring simultaneously the surface and subsurface movement of materials, such as sediments or pollutants,in coastal salt marshes. During this past year, refinements of a computer model that will aid in oil spill response have been completed with Sea Grant and US Navy support.

Advances in biotechnology are helping to develop enzymatic processes for removing some dangerous pollutants from the wastewater of industries that process coal, resin, plastics, oil, chemicals, timber, iron,and steel. Biotechnology has also offered techniques for utilizing a component of shark cartilage as an inhibitor of vascularization within tumor tissue and for recovering heparin, an effective blood anti-coagulant with wide medical uses, from fish wastes. Continuing research into possible uses of chitin, a waste product of shellfish processing, could yield a matrix for the manufacture of specially engineered foods and a capsule for fish larvae feed.

Sea Grant administers the Henry L. Doherty professorships to support young, promising faculty members whose research interests focus on contemporary problems in ocean science and utilization. Harold F. Hemond and Michael S. Triantafyllou are the current Doherty professors.

EDUCATION

Sea Grant's educational projects have several aims: to train young people for marine careers, keep practicing professionals abreast of the latest university research developments, and help the public to realize the tremendous potential of using and managing ocean resources. Students in a 1983 spring design course gained valuable experience by working on a floating production system with novel characteristics to minimize response to wave excitation. In cooperation with the Undergraduate Research Opportunities Program (UROP), MIT Sea Grant aided 11 students working on a wide and exciting range of research projects. Students from MIT and other universities had an opportunity to attend a major Sea Grant conference on Arctic Technology and Policy: An Assessment for the Next Decade. Over 180 people from government, industry, and universities met March 2,3,4, 1983, to identify science, technology, and policy requirements for efficiently recovering oil and gas resources from Arctic waters. The proceedings, being published by an international firm, will be available in September of 1983. The Dean A. Horn Undergraduate Award, established in 1982 to honor the contributions of a former Sea Grant director, was given to John F. Piotti, to carry out a study of federal government's impact on offshore development.

During the past year, Mr. Pariser, director of the education component of Sea Grant, worked to complete teaching modules which had been certified by the Commonwealth of Massachusetts to introduce marine and aquatic subjects to students and teachers throughout the state. The modules are currently being reviewed for national certification and dissemination. As an authority on the development of underutilized fisheries, Mr. Pariser was asked to serve in an advisory role by the Inter-American Development Bank. In the past year he helped to conduct a survey of fish processing technologies in four Latin American countries to determine the potential for expanding the supply of available protein through innovative uses of large, untapped fish resources.

ADVISORY SERVICES

The advisory services of Sea Grant link the resources of MIT to the national Program network and to those people in government and industry who can make use of university research. The Massachusetts Marine Liaison Service (MMLS), headed by Mr. Clifton, focuses on the needs of local and regional groups, although much of the staff's work is also of national importance. Through MMLS, the Naval Ship Research and Development Center in Bethesda, Maryland, has made its large and sophisticated towing tank and circulating water channel available for fishing gear research. In another effort to aid the fishing industry's drive to modernize and compete for international markets, MMLS and the Massachusetts Maritime Academy have established ongoing short courses and seminars.

Sea Grant's Collegium, led by Mr. Doelling, was organized as a complement to the Industrial Liaison Program to serve the interests of marine-related industries and government agencies. Workshops bring MIT's faculty and students together with researchers from other universities and with the Collegium's 100 member companies to germinate new ideas and share expertise. In the past year four special meetings were held: Corrosion Degradation in the Marine Environment, a joint program with ILP; Metal Fatigue in the Marine Environment, took place at the University of Louisiana in Boca Raton; Wastewater Management: Technical Alternatives and the Regulatory Outlook; and Digital Acoustic Telemetry.

An important role of the Collegium is to serve as a catalyst for cooperation and mutual support for the marine-related interests of industry, universities, and government. A highly satisfying example of this has occurred within the unmanned, undersea vehicle effort. Within the past two years, five representatives of government agencies have joined MIT faculty and students to develop underwater vehicle technology, and in 1982, the Perry group of oceanographic companies loaned MIT a remotely operated vehicle for future research. In another effort, students in the Alfred P. Sloan School of Management conducted a marketing study of an underwater stud welding gun, and after a meeting with manufacturers, marine contractors, commercial divers, and the Program's advisory staff, it was decided to field test the gun prior to modifying and test marketing the patented technology.

The Communications/Information Service continued its report series, established in 1970 to disseminate the Program's research results. A newsletter, the Quarterly Report, continued in its fourth year. The publication describes ongoing projects to marine professionals who will ultimately use the results and could contribute support and expertise to the research process. The Sea Grant Marine Information Center, a small reference facility open to the MIT community and the general public, published its ninth annual directory of all MIT marine-related research. In the fall of 1983, the staff will publish a comprehensive overview of the legal, scientific, and engineering aspects of the ocean discharge of municipal wastes, a topic of great current concern.

At the present time, Sea Grant's federal budget uncertainties have lessened. Strong backing from the marine community and the firm support of many in Congress seem to ensure the continued vitality of this university-based marine research program. It will, however, still be necessary to monitor carefully all projects and activities for their relevance and effectiveness in providing research and education benefits to a broad spectrum of citizens who have a stake in the development and management of ocean and coastal resources.

CHRYSSOSTOMOS CHRYSSOSTOMIDIS

Summer Session

Special Programs

The Summer Session Office administers an extensive series of one- and two-week Special Programs for professional men and women who wish to keep pace with developments in their fields. This activity has prospered each summer since its initiation in 1950.

The total registration of 1,426 in the 1982 programs was significantly lower than the registrations of 1,893 in 1980 and 1,887 in 1981. A total of 46 subjects was offered; an additional 11 were cancelled due to low applications. Clearly this reflected the condition of the general economy.

Regular Subjects

Graduate students comprise 80 per cent of the student body in summer. The 1982 registration of 2,454 students was a minor increase from the 2,364 in 1981.

FREDERICK J. MCGARRY

Technology Adaptation Program

The Technology Adaptation Program (TAP) is an interdisciplinary research program with a primary objective of promoting an awareness on the part of faculty and students at MIT, as well as foreign students and scholars who attend MIT, of the technological problems facing developing countries. This objective is met by encouraging faculty participation in specific, well-defined research projects with faculty collaborators from academic institutions in certain developing countries. In addition to the research projects, TAP has conducted a wide range of academic activities including: development of informal institutional ties between MIT and foreign universities, research institutions, and government organizations in developing countries; educational opportunities at MIT for those interested in issues of technology and development, such as interdisciplinary master's degree programs, graduate research assistantships, and visits by foreign scholars; conferences, workshops, and seminars; and dissemination of information through publication of technical reports, working papers, and proceedings of its conferences.

ORGANIZATION

The Technology Adaptation Program is organized according to the following principles:

1) The program relates to those research activities for which there exists faculty support and faculty willingness to participate. The program does not undertake research projects which require large-scale non-faculty staffing. The research activities are supervised and conducted by faculty members, and are administered through their respective home departments.

2) The program committees are composed of MIT faculty members and the program director (who is also a faculty member), thus maintaining academic quality control not only in the conduct of research and educational obligations, but also in the selection of topics for research and the institutions with which the program develops educational ties.

3) The program's activities are carefully scrutinized by appropriate Institute committees such as the Committee on International Institutional Commitments. The Institute is consulted in the early stages of negotiation on all potential sources of funding, including public and private sources both in the US and abroad.

The Technology Adaptation Program is organized with the following basic components:

1) The program director, Professor Fred Moavenzadeh of the Department of Civil Engineering, is responsible for the coordination of all resources utilized for the program.

2) The TAP Policy Committee is chaired by Professor Nazli Choucri of the Department of Political Science (who is also associate director of the program). Members are Professors Moavenzadeh, Daniel M. Holland of the Sloan School of Management, and Jack P. Ruina of the Department of Electrical Engineering.

3) TAP Advisory Committee, composed of the deans of the schools, Professors Choucri and Moavenzadeh, and chaired by the Provost, is responsible for overseeing TAP activities and advising on Institute policies and administrative procedures.

Jeanne De Pass is the program's administrative officer and Kevin J. O'Toole serves as the technical officer. Robert P. Greene serves as the MIT/TAP representative in Cairo.

TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

In January 1977, TAP entered into an agreement with Cairo University to establish a collaborative program on science, technology, and development. This program, which has been funded by the US Agency for International Development (AID), has as its principal objective the development of capabilities within Cairo University to contribute to the formulation and implementation of science- and technology-related policies designed to assist Egypt's development goals. To this end, three specific objectives have been pursued: 1) mobilization of academic interest in research on specific development plans; 2) organization of technical research in collaboration with Egyptian government ministries; and 3) establishment of an institutional framework under Cairo University auspices capable of mobilizing research and educational activities of Cairo University faculty, staff, and students.

To achieve these objectives, a series of activities was initiated, including:

* A set of collaborative research projects among faculty members of Cairo University, MIT, and representatives of appropriate government agencies and ministries in Egypt focused on the development needs of Egypt.

* Educational exchange opportunities through which Egyptian participants would come to MIT for special research-related instruction as well as for degree-granting programs.

* Mini-research projects designed to encourage the participation of Cairo University faculty in research for both the public and private sectors.

* Fellowship programs at the postdoctoral and doctoral level for faculty and graduate students of Cairo University, which would encourage participation in development-related projects in Egypt.

* Industrial internships to provide Cairo University faculty with an opportunity to become familiar with the operations of government ministries and public enterprises.

* A series of conferences, workshops, seminars, and short courses focused on program research activities and findings.

* The establishment of the Development Research and Technological Planning Center (DRTPC) at Cairo University to provide a permanent institutional mechanism for sponsored research and educational activities.

The development and conduct of these activities were predicated upon employment of three general analytic approaches: 1) engineering analysis and technical project evaluation, addressing specific technical issues, including field and laboratory studies, design, and training requirements; 2) economic analysis, focusing on project sector and national planning issues, and micro- and macro-economic studies related to specific Egyptian development programs; and 3) social science analysis of population and labor force issues, socioeconomic change including urbanization, extension of social services, and technology transfer strategies.

Since 1977, 20 collaborative projects have been developed between MIT faculty members, their counterparts at Cairo University, and the appropriate ministry or government agencies in Egypt. The projects focus on a broad range of engineering, economic, and social science topics. The key element in each of these efforts is the interdisciplinary team drawn from faculty and staff from Cairo University, MIT, and government ministry personnel responsible for development of research projects oriented toward the national development needs of Egypt.

Development-oriented research serves several objectives at Cairo University including developing national capabilities in the field of science, technology, and development; providing a vehicle for education of future generations of engineers and scientists; and allowing for substantial increase in the volume of contract research.

The thrust of the program and its dedication to the advancement of current Egyptian development programs have created a strong desire on the part of Cairo University faculty for an opportunity to participate in the program, and for the Cairo University administration to lend its strong support and cooperation. The research projects, educational opportunities provided by conferences, workshops, and short courses, and fellowship programs have upgraded the technical capabilities of the faculty and graduate students, and developed a nucleus of individuals who have an awareness of and interest in the contributions which can be made by the academic community in achieving the development goals of the Egyptian government. The professional ties and relationships established with MIT faculty, Egyptian ministry personnel, and officials of international organizations have proven to be solid and long-lasting.

In February 1983, AID completed a second evaluation of the program and recommended that it be extended for an additional three years at the same level of funding. Contract negotiations are expected to be completed by October 1983.

Since the inception of the program, a period of six and one-half years, $19.2 million has been expended. Student support has been the highest category of expenditure (23%), followed by faculty support (16%). Administrative staff expenditures have been kept at 13 percent in spite of the requirement to maintain an office in Cairo. Research funds have been utilized in four of the Institute's schools as follows:

Engineering	4 departments	60%
Humanities and Social Science	2 departments	22%
Architecture and Planning	2 departments	16%
Sloan School	1 department	2%

RESEARCH PROJECTS OF THE TECHNOLOGICAL PLANNING PROGRAM IN EGYPT

The research projects have focused principally on four broad areas: 1) energy, including electricity generation and distribution, and Egyptian oil resources, including production, processes, and consumption; 2) manufacturing, including small-scale industries, plastics, and building materials; 3) public works, including housing, transportation, and water resources; and 4) socioeconomic development, including population migration, health care delivery, economic planning, and rural communications.

Energy

Long-Term Investment Planning for the Egyptian Electric Power System. The objective of this project is to help develop professional skills in applying tools from mathematical economics and operations research to analyze project alternatives for Egyptians concerned with planning electric power projects. This project is under the direction of Professor Martin Weitzman (Department of Economics) and Professor James Kirtley (Department of Electrical Engineering and Computer Science). Dr. David Woodruff assists in this project.

Energy Policy: Petroleum. The objectives of this project are to examine energy/economy interactions, specifically the role of petroleum in the Egyptian economy, in terms of quantities and pricing; to analyze the effects on the petroleum sector of alternative levels of investments in exploration and development; to examine resource flows domestically and internationally associated with the petroleum sector; and to identify pricing policy issues facing the government. This project is under the direction of Professor Choucri (Department of Political Science). Dr. Supriya Lahiri is contributing to this project.

Energetics in the Egyptian Metal Industries. The objective of this project is to study and recommend methods of bringing about near-term and long-term improvements in the aluminum and iron-and-steel industries. The project is under the direction of Professor David Gordon Wilson (Department of Mechanical Engineering). Dr. Eric Adams assists in this project.

Energy and Environmental Impact Studies for the Qattara Depression Project. The objective of this project is to develop mathematical models to predict the time variation in water level and salinity of the future Qattara Lake. This project is under the direction of Professor Donald R.F. Harleman (Department of Civil Engineering).

Manufacturing

Engineering Applications for the Plastics Industry. The objective of this project is develop a capability at Cairo University, and in several private and public companies, that will support the ministries' plans to broaden the application for plastics materials. The project is under the direction of Professor Frederick McGarry (Department of Materials Science and Engineering).

Production Planning Methodology for the Egyptian Automotive Industries. The objective here is to design a new system to plan and control assembly, fabrication, and procurement in the Industrial Vehicle Division at El Nasr Company. The project is under the direction of Professor Gabriel R. Bitran (Sloan School of Management).

Public Works

Intercity Multimodal Transportation. The objective of this project is to develop a methodology that will make possible the systematic analysis of future transportation investment policy proposals in Egypt. The methodology, which addresses both intercity freight and intercity passenger movements on highways, railways, and inland waterways, will complement previous transportation planning efforts in Egypt. This program is under the direction of Professor Moavenzadeh. Research Associates Michael Markow, Brian Brademeyer, and Dr. Morteza Salehi in the Department of Civil Engineering are contributing to this project.

Stochastic Model of the Nile Inflows to Lake Nasser. The objectives of this project are: 1) to develop computer-based stochastic simulation models which represent Nile River stream flows for use in planning of the water resources systems; 2) to model the hydrologic behavior of the Nile swamp to allow prediction of the water yield taking account of uncertainty; and 3) to develop forecasting models for use in reservoir and irrigation systems operations. This project is under the direction of Professors Rafael Bras and Peter Eagleson (Department of Civil Engineering).

Water Resources Planning Models for the Nile River Basin. The objective of this project is to identify and evaluate alternative water resource development plans and their economic, physical, and social impact. This project is under the direction of Professor David Marks (Department of Civil Engineering).

Performance of Paraffinic Asphalt-Cements in Egyptian Road Construction. The objective of this project is to evaluate the properties of the Egyptian waxy asphalt cements and improve the performance of Egyptian pavements constructed by means of these asphalts. The project is under the direction of Professor Mohsen Baligh (Department of Civil Engineering). Professor Amr Azzouz of the same department is also contributing to this project.

Infrastructure and Urban Planning Guidelines for Secondary Cities in Egypt. The objective of this project is to study methods whereby the use of infrastructure can improve urban land development patterns. The project is under the direction of Professor Ralph Gakenheimer (Department of Urban Studies and Planning) and Professor Nabeel Hamdi (Department of Architecture).

DEVELOPMENT RESEARCH AND TECHNOLOGICAL PLANNING CENTER AT CAIRO UNIVERSITY

The concept of establishing a permanent institution, to foster and encourage research by Cairo University faculty and students on topics relevant to the developmental objectives of Egypt, was an outgrowth of the successful experience of the collaborative effort between Cairo University and MIT in the Technological Planning Program. In order to sustain these efforts, Cairo University established in 1979 the Development Research and Technological Planning Center (DRTPC) as an autonomous research unit, and provided it with more than 2,500 square meters of space in a new building on the campus. The center is currently providing an institutional mechanism at Cairo University for conducting contract research in the area of science, technology, and development.

EDUCATIONAL OPPORTUNITIES

TAP has expanded educational opportunities both at MIT and in Egypt. Opportunities for learning have been made available to both faculty and students interested in general or specific topics related to transfer and adaptation of technology, and valuable experience on specific, real problems has been gained. The projects have provided an opportunity for future decision makers to serve as apprentices under experts in particular areas of technical and economic development. Some of the more specific educational opportunities offered during the past year include those outlined below.

Research Assistantships

The number of graduate research assistantships offered by the program has shown a steady growth since the initiation of the program in 1976. To date, 147 research assistantships have been in effect. Thirty-five theses (15 at the Ph.D. level) have resulted from these assistantships.

Visiting Fellows Program

The program sponsors a small group of Egyptian students who apply and are accepted to graduate programs at MIT. During the past year, five of the visiting fellows received their Ph.D.'s and one received the Degree of Civil Engineer.

Master's Degree Program at MIT

TAP provides educational and research opportunities for master's candidates who are interested in the transfer and adaptation of the technologies of their own areas of specialization to the needs of developing countries. Students who elect this opportunity devise an educational program which includes those subjects required for their chosen area of concentration, and at least one subject which deals with management techniques of special importance to developing countries, one graduate subject in economics which is related to developing countries, one subject in the social sciences area which deals with structures required to support the applications of technologies, and one subject in an engineering area related to the transfer or adaptation of new technologies in developing countries. Twelve students this past year received financial support in the form of research assistantships associated with current TAP research projects.

Visits by Foreign Scholars

To date, more than 190 Egyptian participants from Cairo University and various government agencies have visited MIT. Some have attended short courses on specific topics, while others have followed more informal programs designed to increase their awareness of current developments in their fields. During their visits to the Institute, most of them also have performed work on the specific research projects in collaboration with their MIT counterparts. In addition, several have had the opportunity to meet with other MIT staff members interested in similar problems of technology adaptation and development.

Conferences, Workshops, and Seminars

Each year the program conducts a major conference in Cairo. In January 1983 a symposium on Energy and Development was held at the DRTPC and provided an opportunity for representatives from Cairo University,

MIT, the government of Egypt, and AID to discuss the pressing problems of energy supply and demand and their impact on both the development process and science and technology policy. Dr. Paul E. Gray visited Cairo during this period and participated in both the symposium and the round table discussion that followed. In addition to President Gray, presentations were made by two government ministers, the Deputy Director of AID, and the President of Cairo University.

Following the symposium, a two-day technical conference was held to report on the research accomplishments of the projects. Six of the research teams conducted workshops in Cairo during this year. These workshops were held in the following areas: Energy in the Egyptian Economy, Design of Irrigation Structures, Opportunities for Solar Ponds in Egypt, Energetics in the Egyptian Metal Industries, Urban Planning, and Processing Technology in Plastics.

Administrative Support

In supporting the institutionalization effort of the DRTPC at Cairo University, MIT administrators have visited Cairo to work with the Egyptian managers. George Dummer, Director of the Office of Sponsored Programs, and Philip Keohan, Comptroller, have been to Cairo and, with their staffs, are assisting in the establishment of accounting systems and contract management procedures for the DRTPC. This effort will be of a continuing nature.

Publications

TAP publishes its own series of technical reports in addition to those papers which are included in the broader area of the principal investigator's journals. Since the start of the Egyptian project, more than 350 papers and reports have been published.

OTHER ACTIVITIES OF TAP

In September 1982, a workshop was held at MIT with the President of the Technical University of Berlin to explore the possibilities of developing a collaborative arrangement between the two institutions with a focus on a third developing country. At this workshop it was concluded that both the international interest and research capabilities were complementary and a joint program should be pursued with the countries of Portugal and Turkey. In March 1983 members of the TAP Policy Committee and representatives of TUB visited the Universidade Technico de Lisboa and the Universidade Nova de Lisboa in Portugal and the Middle East Technical University in Ankara, Turkey, to further explore a collaboration. The level of interest was high and a joint proposal is being prepared for submission to international organizations.

FRED MOAVENZADEH

Undergraduate Research Opportunities Program

Media highlights for this year included the showing in November of *Young Scientists*, a WGBH-originated program from the NOVA science series filmed partially at MIT and featuring an Undergraduate Research Opportunities Program (UROP) student, a faculty supervisor, and UROP Director, Professor Margaret MacVicar; a meeting of UROP students and a representative from a film studio working for Walt Disney Studios; and lastly, UROP's inclusion as a national model of excellence in the Department of Education report of the Commission on Excellence in Education. Professor MacVicar was invited to deliver an address describing UROP's role in MIT education at the University of Compiegne in celebration of its tenth anniversary as France's "MIT." In the 1982-1983 *Selective Guide to Colleges* prepared by *The New York Times* education editor Edward B. Fiske, UROP is described as "the best student and faculty research program in the nation." Fame has spread, interest from alumni and from other institutions has broadened, but the original UROP spirit of lively collaboration between interested parties, student and mentor, prevails.

Changes that have occurred in the thirteen years since UROP's beginnings in the fall of 1969 have been changes of scale and scope, but not of substance. Numbers have changed significantly: participation of both faculty and students has risen. The number of students participating set another record this spring for the second year in a row. Correspondingly, demands for research funding by undergraduates during this past year were considerably higher, the number of requests for summer alone exceeding the previous summer by nearly 40 percent. Other numbers have not changed: the UROP research stipend support remains at $4.50 an hour. We have been unable to keep pace with the inflation rate since 1972.

Popularity and the eroding student wage base, undercut in recent years by rapidly rising tuition and costs, have placed us in a dilemma: Should we limit the number of participants in order to allow higher individual stipends, or should we continue to allow an ever increasing distance to develop between the UROP minimum wage and the Institute student employee minimum wage? This issue was met head on again this year in the Student Wage Review Committee of which UROP Associate Director Norma McGavern is a member. A decision, supported by the Financial Aid Office and opposed by UROP, to continue to link tuition costs with the student employee minimum hourly wage rate led to a new Institute general minimum of $5.25 an hour, which UROP decided not to honor from its direct general funds but only when faculty offered sponsored research funds. This wages trend, should it continue, both raises the obstacle threshold for inexperienced beginners to ever be hired as employees on the student payroll, and can leave UROP researchers disconcertingly far behind.

This academic year faculty-sponsored research contracts support continues to be the only growth source of funds for UROP support. Fortunately, faculty respond handsomely to UROPer needs. This academic year, faculty-contributed stipend support to UROPers was 65% higher tnan last year, which was itself higher than any previous year.

Program administration, however, has largely remained unchanged in its cost in actual dollars for more than a decade. Help in stretching our limited resources for student stipends and materials and services, and at the same time rewarding outstanding research, has fortunately been met especially well this year via the award funds UROP administers. A personal solicitation by Professor David Jansson, chairman of the Clapp and Poliak Engineering Design Award Committee, yielded an additional $10,000. Of this amount, $1,000 will be given each year to the Clapp and Poliak scholar who has, in the view of the Committee, accomplished the best piece of original engineering work in the previous year. The first winner will be awarded in the fall of 1984. This has been a bright year for Clapp and Poliak scholars. Recipients were: four undergraduates working on the Goddard Project in the Department of Aeronautics and Astronautics, a project directed toward designing a satellite-launching rocket; five students with original design ideas in the Department of Mechanical Engineering; and a student working on computer-aided ship design in the Department of Ocean Engineering. Three Eloranta Summer Research Fellowships of $4,000 each were awarded to: Gloria Lee, Class of 1983, who plans to travel to the People's Republic of China to research an oral history of the Long March; Duncan Borland, Class of 1983, for the writing of a book about multiple sclerosis; and Kenton Yee, Class of 1984, to study the electron in curved space-times with Professor Philip Morrison.

The generosity of Dr. Edwin H. Land, former president and chairman of Polaroid and now president of the Rowland Institute for Science, will make possible four $4,000 Eloranta Summer Fellowships in the summer of 1984. Sea Grant, which supports undergraduate research in areas related to the study and management of the oceans, awarded support to four undergraduates in the fall term and five in the spring. The strong response by students this year and the outstanding work done to date has encouraged a 100% increase (to $10,000) in Sea Grant support to undergraduates for the next fiscal year. New England Life Insurance Company President John A. Fibiger met with Dr. Paul Gray and the first six undergraduate recipients of

its awards for research in medical and health-related topics, awards which allow $30,000 in support over a five-year period. This year the Class of 1972 UROP fund was established to support UROP work designed to improve the quality of life through its impact on people and/or the environment. First awards will be given next year.

The Class of 1970 awards went to two undergraduates this year, one studying the health effects of radiation, the other for developing self-help aids for tenants facing eviction without legal representation. The MIT Chapter of Sigma Xi offers support for materials and services for worthwhile projects in applied science, this year rewarding a student working on artificial skin, and enabling another student to attend a conference of the American Society for Metals and present the results of his research in arc welding. Both recipients of Sigma Xi support were invited to the Chapter's annual MIT banquet. James McCormack Fund support, which aids undergraduates doing research in areas relating to technology and its applications to problems of mankind, society, and the arts, was given to two students, one studying the toxicity of certain combustion fuel by-products, the second studying the characterization of the structure and nature of early frit porcelains. Uniroyal Foundation support went to five beginning researchers as it has in previous years. The Civil Engineering Department again offered beginning researchers in that field first-time stipends of $600 apiece to ten promising students. The Joel Matthew Orloff UROP Prize given in the spring of 1982 for the first time, will be given in the fall of 1983 instead of spring so that it does not compete with the myriad awards given at term's end.

Last year's gift from Raymond Stevens, Class of 1917 and formerly president of Arthur D. Little and a member of the MIT Corporation, given to help undergraduate researchers learn how to speak effectively in public, was put to work during Independent Activities Period (IAP). Staff member Ms. McGavern ran a four-day workshop on "How to Give Speeches and Make Technical Presentations." Interest ran high and an undergraduate seminar is being planned for next spring. Assistant Director Michelle Lamarre ran an afternoon workshop for students on how to find and get going in research, "Starting Out or Starting Over." A third IAP activity was a brief workshop for potential Eloranta Summer Fellowship applicants, given by Ms. McGavern.

The interest of MIT alumni in the experiences of UROP students was demonstrated again with an invitation to two undergraduates, Anjali Sastry, Class of 1986, and Vincent McNeil, Class of 1984, to address the New Haven Alumni Club, and a repeat invitation to undergraduates, this year to Susan Flynn, Class of 1983, and Keita Ito, Class of 1985, to address the Northern New Jersey Alumni Club. Enthusiastic responses to these presentations has apparently convinced alumni of the effectiveness of student speakers, especially when these speakers are scheduled at the time of year when potential incoming MIT freshmen can be invited to attend. Preparations are underway for a September 24th UROP presentation to the annual meeting of the National Alumni Conference, UROP's second such invitation.

UROP Director Professor MacVicar was promoted to full professor, effective July 1, 1983. From that date, she will assume her new appointment as vice president of the Carnegie Institution of Washington, D.C., on partial leave from MIT during the fall term. She will work closely with Carnegie's president, Dr. James D. Ebert, on research and education policy. Ms. McGavern will oversee day-to-day operations during that period. Clifford Truesdell, UROP assistant director since 1979, left in January to become legislative aide to Cambridge State Representative Peter Vellucci. He has not been replaced, and his responsibilities have fallen to other staff members, Ms. McGavern and Ms. Lamarre. Louise M. Harrigan joined the staff in July 1982 as our main-building link in Professor MacVicar's office. Gregory Smith continues as our special projects coordinator in addition to his activities on behalf of the Council for the Arts. Marcia Cassidy, a graduate student at the New England Conservatory of Music, this fall replaced what would have been a series of part-time temporary clerical office assistants by becoming our permanent part-time office assistant. In the summer of 1983 this role will expand into full-time office assistant as she substitutes for Office Manager Susan Mitchell-Hardt, on leave to have her second child. Shifting responsibilities encouraged us to make some physical office rearrangements in the spring, and to begin the process of acquiring long-needed storage and overflow space in an additional room in Building 20.

MARGARET L.A. MACVICAR
NORMA G. MCGAVERN

Upward Bound Program

The MIT/Wellesley Upward Bound Program is a coeducational, multiracial, multiethnic educational program for Cambridge high-school youth. Now in its sixteenth year, the program services 70 academically promising young men and women who come from disadvantaged backgrounds. The goal of the program is to motivate these youths to attend college, and to provide them with the necessary academic and social skills needed to succeed in college. To a large extent, the program is influenced by the research done in the 1930s and '40s by social psychologist Kurt Lewin and his associates. The program has met with good success, operating on the assumption that ego growth and academic performance are closely related. A developing ego needs to experience success in a warm and personal but structured environment to develop strongly, in both a personal and social sense. This development can be brought about through intervention outside of the family and school.

Upward Bound represents such a controlled field intervention. It has established that the effects of failure can be reversed by presenting the young person with real success, and that further success leads to an increase in the student's level of aspiration. The program staff are often the first to see real academic promise in the youngsters. The staff, together with teachers and fellow students, play a crucial role, because what students think they can do is dependent on what others think they can do. The students' perceptions of their abilities, and therefore what they will try to accomplish, are thus to a large extent determined by the staff.

Summer Program

The summer program, conducted in residence on the Wellesley College campus for six weeks, is designed to provide the student with an intense academic and social experience. Classes are team-taught by experienced high school teachers, students from Wellesley College and MIT, undergraduate and graduate students from local colleges and universities, and Upward Bound alumni now attending college. Upward Bound students carry three classes, each of which meets for an average of 60 minutes per week, during the six-week summer program. Each student is required to take a mathematics and an English course and one elective. Humanities and social science offerings include film studies, religion and world views, US history, social psychology, and cultural identity in America. Science courses include biology, physics, human physiology, computers, and chemistry. The mathematics program includes an enrichment section for students who have done poorly in algebra I or II, geometry, or trigonometry; and pre-calculus and calculus courses for students who will be attending college in the fall.

The Academic Year

The academic year program, while less intense, is equally important to that of the summer. Building on the motivation and enthusiasm developed over the summer, the academic year program is designed to help the student cope with the myriad academic, social, and family problems that confront him or her in Cambridge. To achieve this, the following programs, staffed primarily by MIT and Wellesley undergraduates, have been developed and implemented.

Study Skills. The MIT Upward Bound offices are open for study two days a week from 3 to 6 P.M., and two days per week from 3 to 9 P.M. In addition, tutors are available in the offices on Sunday from 1 to 4 P.M. Tutors are on duty to provide homework supervision for both individuals and small groups. Tutors are typically MIT or Wellesley College undergraduates who meet regularly with the core staff to discuss students' progress and/or difficulties.

Tutoring. Whenever requested or needed, tutors are assigned to individual students. These pairings meet on a regular basis at a specified day and time until it is mutually agreed that the individual tutorials are no longer necessary (usually indicated by improvement in grades). Organization and time management are stressed, as well as effective negotiation techniques.

College Report, Class of 1983

Graduating seniors have been placed in colleges as follows: North Adams State College, Fitchburg State College, Denison University, Wesleyan University, Boston College, Wheaton College, Vanderbilt University, North Carolina State, Bentley College, Salem State College, Northeastern University, Adelphi University, Norfolk State University, Westfield State College.

We are looking forward to increased participation by MIT and Wellesley College undergraduates through our continued involvement in the course practicum placements of MIT seminar 212 and the Wellesley College Teacher Certification Program.

RONALD S. CRICHLOW

Wellesley-MIT Exchange Program

Now in its fifteenth year, the Wellesley-MIT Exchange was established to expand educational opportunities for students of each institution. That goal remains.

Cross-Registration

Central to the Exchange is a cross-registration program which offers students a wider range of course options, teaching styles, and classroom environments.

In recent written evaluations of their MIT subjects, students emphasized the welcome change they found at the other school. Wellesley students commented:

> It's good to get away from Wellesley and see what another learning environment is like -- especially when it is MIT.
>
> Great to be in a class with students from all over the world -- graduate students with first-hand experience of how "cultures" really function. Discussion was always animated.
>
> I really enjoy interacting with MIT students on an academic "business" level. Their perspective on schooling is so different from that of the typical liberal arts major at Wellesley.
>
> MIT is a special experience. Intimidating? Yes. But important to experience? Definitely.

MIT students have equally positive comments about the value of a different educational experience:

> I very much enjoyed going out to Wellesley each week. It was a nice change from the MIT environment.
>
> Good opportunity to get away and meet new people. The way of thinking is much different than at MIT. This difference helps to keep your mind open and challenged.
>
> I like the approach and atmosphere at Wellesley.
>
> Good discussion -- fresh ideas ... I guess the people were the best part of the course.

The number of cross-registrations between the two institutions remained high this year. During first semester, cross-registrations were almost equal: 144 MIT students enrolled in 178 Wellesley subjects while 147 Wellesley students took 201 MIT subjects. During second semester, Wellesley cross-registrations were the highest in eight years--234 students in 310 MIT subjects, while MIT enrollments remained at a more normal level--158 students in 186 Wellesley subjects. These spring 1983 enrollments were the reverse of those of the previous spring when MIT cross-registrations were the highest in a decade.

Joint Courses

Holly Reynolds, assistant professor in Wellesley's Religion Department, taught two courses on the MIT campus: Religion 252 The Islamic Tradition during the first semester and Religion 108 Introduction to Asian Religions during the second semester.

During second semester, Jean Jackson, associate professor of anthropology at MIT, and Sally Merry, assistant professor of anthropology at Wellesley, offered at Wellesley a new joint rotating seminar -- 21.597 (Wellesley Anthropology 346) Colonial Development and Nationalism: The Impact of the State on Traditional Societies. In addition, the faculty of the Center for Materials Research in Archaeology and Ethnology continued to offer at MIT 21.544 (Wellesley Anthropology 308) Materials in Ancient Societies: Ceramics.

Wellesley and MIT subjects offered as part of the Cambridge Humanities Seminar included two first-semester subjects at MIT, 21.171 Literary Interpretations and 24.621 Philosophy of Art, and two second-semester subjects at Wellesley, 21.979 (Wellesley Philosophy 304) Theory and Practice of Metaphor, and 21.980 (Wellesley Philosophy 328) Painters and Philosophical Issues in Modernism.

Wellesley Double Degree Program

During the year, the Wellesley-MIT Joint Committee developed procedures that would allow a very small number of Wellesley students who are accepted to MIT as transfer students to earn a B.A. degree from Wellesley and a B.S. degree from MIT over the course of five years. These procedures were approved by the Committee on Educational Policy at its April 28 meeting.

Interested students may apply for transfer admission to MIT at the end of their sophomore year. Their applications will be reviewed on the same basis as those of other transfer students. They will be subject to the same admissions criteria and financial aid policies, and access to a given department may be limited at times.

If accepted for transfer to MIT, students will fulfill requirements for a major at both institutions. MIT will permit Wellesley transfer students to defer enrollment and complete their junior year at Wellesley. During this "bridge" year students will be assigned major advisors at both institutions. During all five years they will be able to integrate studies at both institutions through cross-registration.

Joint Wellesley-MIT Teacher Certification Program

The Massachusetts Department of Education has approved a Joint Wellesley-MIT Teacher Certification Program, with Wellesley as the certifying institution. Wellesley and MIT students seeking teacher certification must take five subjects, three offered at Wellesley and two offered at both Wellesley and MIT. They have the option of doing their student teaching through Wellesley in a suburban setting or through MIT in the Cambridge school system.

Residence Exchange

In September, 14 upperclass students from each institution moved into dormitories on the other campus as part of the Wellesley-MIT Residence Exchange. The residence exchange had been reinstituted after a hiatus of more than 10 years.

Participants for the residence exchange were selected by a subgroup of the Joint Committee. Criteria included the students' class year, academic program, and stated reasons for applying for the residence exchange. Preference was given to students willing to make a full-year commitment to the residence exchange.

In applying for the residence exchange, students from both institutions stated their desires for a change of academic and living environments. In mid- and year-end evaluations, they characterized their experiences as not always easy, but worthwhile. Although they had to face the difficulties inherent in being outsiders, both Wellesley and MIT students praised their new environments and said that they had grown intellectually and emotionally. As one MIT student commented, "It was refreshing and enlightening." A Wellesley student said: "I love my hall -- it's alive -- waterfights, Chinese food in Central Square, pizza parties, IM sports, arguments, discussions, late night Scrabble."

Joint Committee and Exchange Staff

The 1982-83 Wellesley-MIT Joint Committee was chaired by Robert J. Silbey, professor of chemistry at MIT, and Edward A. Stettner, dean of the college at Wellesley. MIT members included: Dennis L. Doughty, Class of 1983; Mary Z. Enterline; Dean Holliday C. Heine; Professor Judith T. Kildow; Dr. Louis Menand III; Associate Provost Frank E. Perkins; Brian E. Simmons, Class of 1984; Professor Joseph M. Sussman; Dr. John P. Terry; and Michael P. Witt, Class of 1984. From Wellesley, members were Dean Molly S. Campbell; Professor Theodore Ducas; Barbara Farquahar; Professor Phyllis J. Fleming; Professor Robert D. Frye; Rebecca Grant, Class of 1985; Lynn Hunt, Class of 1984; Dean Elissa Koff; Dean Florence C. Ladd; and Dorothy Moeller.

At MIT, the Exchange Office continued to be staffed by Ms. Enterline, manager, Maryglenn Vincens, staff writer/editor, and George R. Kendall, senior office assistant.

MARY Z. ENTERLINE

Chairman of the Faculty

The Committee on Educational Policy devoted much of its effort during the 1982-83 academic year to issues initially raised in a review of the undergraduate academic program begun by the CEP in 1980. The focus of the review was described in our section of the 1981-82 *Report of the President* and in the President's section of the 1980-81 *Report*. The activities during the past year of the CEP and of several other Faculty Committees are highlighted in the following sections.

Humanities, Arts, and Social Sciences (HASS) Requirement

The CEP reviewed the HASS Requirement during 1980-82 through a subcommittee chaired by Professor Anthony French. The general conclusions were that the present Requirement of eight subjects is appropriate; that the division among distribution, concentration, and elective components was achieving its educational objectives reasonably well; and that MIT students, on average, seem to gain a broad general education in the humanities, the arts, and the social sciences. However, the criteria that govern the Humanities Distribution Requirement were generally considered overly restrictive and conflicting, and the committee mechanism established to enforce these guidelines and other aspects of the HASS Requirement was believed not to have worked particularly well. In October, the CEP supported the initiative of the Dean of the School of Humanities and Social Science to establish a task force which would address these shortcomings. The task force, coordinated by Professor Sylvain Bromberger, undertook a substantial amount of discussion with faculty involved in the teaching of HASS subjects. This work led to major changes, approved at the April Faculty Meeting, in the way the criteria for Humanities Distribution (Hum-D) subjects are to be defined and monitored: a) The current guidelines governing Hum-D subjects were changed to include some general criteria dealing with orientation of content and emphasis on written and verbal expression that apply to all fields, and some discipline-specific criteria to be formulated by each field. b) The HASS Committee was abolished on June 30, 1983, and much of the responsibility for monitoring Hum-D subjects was transferred to the individual departments and sections; the Dean of the School of Humanities and Social Science will be responsible for monitoring the overall HASS program, and the Committee on Curricula (COC) serves a general oversight role for the Institute as a whole. c) A guide to the HASS Requirement will be prepared each year to communicate to students and advisors the objectives of the Requirement and help them make more informed decisions with respect to the range of options available. d) Some current problems with the procedures for certifying completion of the HASS Requirement will be corrected. The CEP is indebted to the enormous effort of Professor Bromberger in undertaking much of the work needed to reach consensus on these changes.

Recommendations on the Freshman Year

Background to the CEP's recommendations on the freshman year was provided in last year's annual report. The detailed proposals, presented as an educational experiment through the 1984-85 academic year, were widely distributed in September for comment and, with minor changes, were approved at the November Faculty Meeting. The CEP supports continuation of Pass/No Credit grading during both terms of the freshman year, but, in recognition of some valid criticism of Freshman Pass/Fail, changes were made to strengthen the system. The basic goal of the changes is to improve the effectiveness of advising by giving students and advisors accurate, as well as timely, information for making educational decisions. With help from the Undergraduate Academic Support Office (UASO) in the Office of the Dean for Student Affairs, the CEP took steps to provide more systematic information about the various departmental program requirements, modify the current system of narrative evaluations to provide better information on performance, and provide internal grades for freshmen at the end of the spring term. The internal grade system, while already a part of informal practice, was established largely to help students make the transition to the grading system in the sophomore year and to provide a more complete picture of their freshman year to use in planning the sophomore program. Guidelines have been established governing the use of internal grades, both within and outside MIT. Since the purpose of internal grades is to assist academic advising at MIT and students' self-evaluations, MIT will not send copies of the internal grades to third parties. The internal grade reports (which are prepared in an informal format and not automatically sent to students' home addresses) were used for the first time this spring. Continued efforts are needed to communicate the restrictions on internal grades for purposes other than advising, and to encourage students and faculty to view them in the context of the educational experimentation encouraged in the freshman year.

MIT Pace and Pressure

The CEP continued discussion on the question of the pressure and the sometimes frenetic pace at MIT, raised by President Paul E. Gray in his 1980 Inaugural Address. There are widely divergent views among the faculty and academic administration on this issue, ranging from the perspective that high pressure

should be expected at a first-class place like MIT in producing the most competent graduates ("perhaps we are not demanding enough") to the view that students need more unstructured time for reflection and thus the current pace is detrimental to the broader educational process. To help understand and address specific pace/pressure issues of concern to the CEP, several new efforts were initiated this year. First, the UASO, working with the departments, is developing detailed "roadmaps" which graphically display various pathways (as examples of options) through the departmental programs. The current lack of such planning information can create pressure when freshmen feel the need to take as many subjects as possible in order to protect all options. The initial version of the "roadmaps" will be available this fall, with the intention that they be used in the context of discussions between students and their advisors. Second, a major survey of students undertaken last fall by Dr. David Wiley has identified some particular problems with the pace at the end of the term. The end-of-term pace/pressure, and its effect on performance, appears to be a significant problem for about two-fifths of upperclass students and one-quarter of first- and second-year graduate students. The last week of classes is especially stressful because students often are expected to complete numerous papers, lab reports, and projects while at the same time prepare for final quizzes that week and/or final exams the next week -- all of which may count a great deal in the final evaluation. The CEP believes that a large part of the problem is structural and can be corrected. As part of a summary report published in *Tech Talk* in mid-April, the CEP presented several possible courses of action in order to generate discussion and constructive suggestions on how best to proceed toward a set of recommendations. These discussions will continue in the fall term.

Last August the Chairman of the Faculty, on behalf of the CEP, the Committee on Academic Performance (CAP), and the Committee on Graduate School Policy (CGSP), sent a letter to faculty members encouraging them to take greater advantage of the educational benefits of the reading period and final exam week -- a suggestion which it was felt would help decompress the last week of classes in the fall term. One of the incentives offered was to postpone by a week the final due date for fall term grades in subjects which give final exams. The experiment led to a significant increase both in the number of final exams and in the number of finals of less than three hours. The CEP will repeat the experiment next fall. The CEP also discussed ways to decompress the end of spring term, which currently places severe burdens on students, faculty, the CAP, and the Office of the Registrar as a result of the short period between the end of term and Commencement. Several possible changes in the IAP and spring term calendars were discussed which would lengthen the spring term reading period, allow for a later grade deadline, and provide more time between the end of the term and Commencement. Discussion of these possibilities will continue in the fall.

Content, Coherence, and Intellectual Impact of the Undergraduate Program

The central issue yet to be addressed in the undergraduate program review is how to reconcile appropriately, in a four-year curriculum, MIT's dual goals of general education (leading to a reasonable level of scientific and humanistic literacy) and professional specialization (leading, generally speaking, to a set of marketable skills). Among the issues that have been raised is the fact that students come to MIT with about the same preparation as in former years, yet the level of knowledge and skill where professionalism begins is expanding significantly, suggesting to some people a need to allot more time to the professional training. On the other hand, others feel that greater flexibilities should be built into the curriculum to provide our students more time for elective choice, for reflection, and for taking part actively in our rich and diverse community. These are concerns that reflect the fundamental distinction between the education provided by a university and the training provided by a trade school. Pressures toward vocationalism, though perhaps transient, are reinforced by the increasingly intense career orientation of our undergraduates. Preservation of MIT's uniqueness requires that we continue to provide a range of options, accommodating different educational styles, without either of our dual goals becoming exclusive.

The way the above conflicts are resolved has significant bearing on the content, pace, and structure in the undergraduate program, and specifically on the basic premises that underlie the Institute science requirements, departmental programs, enrollment patterns and diversity, and the overall learning environment. We need to consider in today's context some basic questions about the undergraduate program: What kind of students do we want to attract and what do we want them to have when they graduate? What is really basic in an MIT undergraduate education and what is the overall intellectual impact of what we do and how we do it? How can we most effectively achieve an integrated professional and liberal education, maintaining proper relationship between technical and nontechnical aspects?

General agreement is emerging on the need to examine fundamental questions about the General Institute Science Requirements, which are a significant expression of what makes MIT special. Are they still appropriate and coherent for the 1980s, in terms of both their overall contributions to the educational program and their particular impact on non-science/engineering majors? Addressing the science core, Laboratory Requirement, and Science Distribution Requirement separately: a) Does the current science core properly reflect a modern perspective on what constitutes scientific literacy? What should be the appropriate balance in the core subjects between introducing students to the scientific culture of today and fulfilling preprofessional instruction in "useful" subjects? Should the core place more emphasis, for example, on discrete mathematics, on fundamental life processes, and on the relationship of science and technology to public policy and societal concerns? Are the core topics presented in formats that are well-matched to the diverse backgrounds and needs of entering students? Should some core subjects be deferred to sophomore year?

b) The Laboratory Requirement raises fundamental questions about the emphasis desired in a general laboratory experience: Should students' encounters with this learning process occur in the natural sciences (viewing such experience as an essential part of a broad, liberal education in the sciences), or should its analogue in other fields, such as economics and psychology, also qualify (orienting the Requirement toward how professionals in the field deal with real-world phenomena)? Should the Requirement be restricted to project-type experiences, where the means of data acquisition are part of the learning experience, or should modern lab experience involving manipulation of sophisticated instrumentation also be allowed to qualify? Short of reconceptualizing what the perimeter of the Laboratory Requirement ought to be, an immediate need is to rewrite the current guidelines of the Requirement to express more realistically the range of purposes presently allowed. c) The primary concern with the Science Distribution Requirement is that it does not play the broad, cultural role in science education envisioned at its inception; it makes little sense, however, to propose changes in the Science Distribution Requirement apart from a serious reexamination of the content and rationale for the entire science requirements.

Beyond the science requirements, a number of other concerns have been expressed about the structure and impact of an MIT undergraduate education. Some of these relate to our competing objectives in general and professional education and to the overall culture at MIT (including the competitive nature and pace of the place). For example, some faculty members feel that there is a need to clarify the Faculty Regulations specifying the allowable magnitude of departmental program requirements -- in part to address a conflict between the current provision giving students up to two years of exploration before selecting a major and the actual demands made by some departmental programs. The practice of encouraging students to select a department by the end of the freshman year diminishes flexibility to explore a range of options in the first two undergraduate years. A related question is whether, at the undergraduate level at least, the academic "currency" should be expressed in number of subjects taken, or in credit units, or both. Other problem areas which may adversely affect the learning environment at MIT have been suggested: student frustrations with certain academic services (such as inconsistent advising, difficult-to-reach faculty members, and lack of central supportive resources in some departments); concerns about the quality of instruction (suggesting the need for better incentives for effective teaching, writing textbooks, and developing new subjects); and insufficient attention to our most able students.

The CEP broadly examined the issues outlined above and stimulated discussion on several of them among the senior officers and deans, School Councils, and faculty in a few departments. No consensus emerged on what the important issues are or on how to move forward. There was, for example, resistance to adding any subject to an already crowded science core, and mixed sentiment (especially between Schools) for reexamining the rationale for the entire core. In the absence of a sufficiently high threshold of dissatisfaction and clear signals for change (both of which were present during the Zacharias Committee deliberations in the early 1960s), doubts were raised about the appropriateness of undertaking a major review of the content and structure of the undergraduate program. Part of the problem is the situation we currently face with regard to skyrocketing engineering enrollments, the growing use of computers in education, and the economy.

Nevertheless, by the end of the year there was a belief that the time has come for a comprehensive review. As President Gray has said: "Undergraduate education is the most important of MIT's several missions; the need to address questions related to the content, structure, pace, and impact of the undergraduate program is even greater at this time, if we are to continue deserving the high quality students who choose to come here. We must strive to keep undergraduate education at the high level of distinction judged to be present in the faculty and in the departmental programs."

Because these remaining issues in the undergraduate program review deal with fundamental and sensitive concerns, effective means must be found to broadly engage students, individual faculty, and the departments. It has been nearly 20 years since the faculty as a whole has explored these issues, and this fact alone supports the growing sense of need to move forward. The process will be facilitated by a reorganization within the Office of the Provost that will allow the Associate Provost, Professor Frank E. Perkins, a more sustained level of attention to the important issues in undergraduate education. Under his leadership, several initiatives are being undertaken which will be very helpful in mobilizing departmental interest and support for reviewing the undergraduate program. The mode in which the review will proceed is still an open question.

Catalogue Review

An ad hoc task force consisting of representatives from the CEP, the COC, and the CGSP, as well as from several administrative offices, examined various ways to make the catalogue (*Courses and Degree Programs)* more readable, manageable, and useful to the audiences it serves. These three faculty committees approved several changes for the 1983-84 catalogue: First, the subject description information in Chapter VII will be more helpful and accessible as a result of listing only subjects that will be given within two years, encouraging more uniform practices for the length of subject descriptions, reducing the density of white space, and providing the full descriptions of "J" (joint) subjects and Engineering School-Wide Electives only once in the catalogue -- changes that will reduce the length of Chapter VII by over 100 pages (30 percent). As a matter of policy, it was decided that Chapter VII should provide a dictionary reference to subjects being given and should not duplicate the function of other chapters in displaying departmental and interdepartmental "programs." Second, significant improvements are being made in the organization and readability of

Chapter V, to provide a clearer, more balanced picture of the nature and scope of the opportunities for interdepartmental study and research at MIT. The review process will continue in the coming year, focusing primarily on the description of departmental programs in Chapter VI of the catalogue.

Other CEP Actions

At the recommendation of the Wellesley-MIT Joint Committee, and with support from President Gray, the CEP approved steps to facilitate a Wellesley Double Degree program. In substance it is a Wellesley College program, since Wellesley will offer those students who successfully transfer to MIT and receive an MIT S.B. degree an opportunity to complete their B.A. degree from Wellesley. The program is developed largely within current rules and procedures. MIT will consider applicants for admissions and financial aid on the same basis as all other college transfer applications, but will make provision for a transition year (admission one year in advance of actual attendance) during which students take appropriate advantage of opportunities for cross-registration. The program will be small (three or four transfer students per year), covering the range of fields of study at MIT. In the discussions of the proposal within the CEP, the COC, and the Committee on Undergraduate Admissions and Financial Aid (which also worked out acceptable procedures regarding admissions and financial aid), strong concerns were expressed that the program might reinforce a stereotypical, narrow image of MIT and might send mixed messages to prospective women applicants to MIT. The CEP accepted the program as being in the spirit of the larger Wellesley-MIT collaboration, with the provision that there be a reciprocal review of each institution's description of this collaboration in the respective catalogues and admissions materials.

During the year a number of amendments to the Faculty Rules were agreed upon by the Faculty. Among the more substantive changes were: limiting the number of faculty members *ex officiis* to 28 (with agreement that related concerns need to be examined in greater depth next year); eliminating the irregular September Faculty Meeting (by delegating authority for faculty approval of summer degrees to the officers of the Faculty); making specific provision for canceling a limited number of Faculty Meetings when there is no pressing business; specifying that final examinations shall be scheduled with the Registrar before the end of the third week of the term; and limiting the conditions under which grades, once submitted, can be changed.

Among other actions this year, the CEP: a) forwarded to the Faculty a proposed change in degree title, Bachelor of Science in Humanities, for those Course XXI degree programs whose departmental content is solely in the humanities; b) discussed and forwarded to the Faculty a report from the Committee on the Writing Requirement describing plans for implementing the new Institute Writing Requirement beginning in the 1983-84 academic year; c) reviewed with members of the IAP Policy and Administrative committees evaluations of recent IAPs; and d) approved the manner in which Engineering School-Wide Electives (SWE) will be listed in the MIT catalogue, and ended an educational experiment with the SWE Program that had been overseen by the CEP (with ongoing program administration and development of SWE now fully within the School).

We express appreciation to the Student Committee on Educational Policy for their skill and dedication in preparing the "Student Course Evaluation Guide." The credibility given to the Guide promises to be important in helping enhance the overall quality of teaching at MIT.

Other Faculty Committee Reports

Several chairs of the Faculty Committees have submitted summaries of the major agenda items addressed during the past year. Excerpts from these reports follow:

The Committee on Academic Performance dealt with two policy matters in addition to its regular activities with petitions, grade reviews, disciplinary actions, and readmissions. With the concurrence of the CEP, it decided to reinstate cumulative grade averages on the internal grade reports distributed each term to undergraduates, and decided not to count credit units in ROTC subjects in the freshman load limits or in credit limits imposed upon undergraduates who received CAP warnings.

Beyond the review of new departmental curricula, new subjects, and student petitions for deviations from Institute requirements, the Committee on Curricula was a principal planner and administrator of refinements made this year in the Descriptions of Subjects section of the MIT catalogue. Other COC concerns included cross-registration policies and practices with other universities, the revitalization of the undergraduate seminar program, and the development of more satisfactory procedures for the oversight of new curricula and subjects.

The major agenda for the Committee on Undergraduate Admissions and Financial Aid (CUAFA) was the issue of need-based admissions and merit-based aid, discussions which paralled those in the Academic Council's Task Force on Financial Aid. CUAFA strongly reaffirms faculty support for MIT's current need-based financial aid policy and merit-based admissions policy. The Committee finds the notion of need-based admissions abhorrent. Beyond the obvious problems with merit-based aid, such as its effect on the campus atmosphere, the Committee finds that there is insufficient data at the entry level to predict how a student will do at MIT, and certainly not enough to make merit-based aid decisions nor to place some students in a

second-class status by virtue of such decisions. The Committee also finds a wide divergence of views regarding criteria that would be appropriate for merit-based aid decisions at the upperclass levels. It is particularly important that the faculty makes its voice heard on these difficult issues, since their resolution will shape, in important ways, our student body in the years to come. The Committee also reviewed MIT's general financial aid policies for transfer students, as part of its discussions on the Wellesley Double Degree proposal (reported above under the CEP agenda).

In preparation for implementing the Institute Writing Requirement next fall, the Committee on the Writing Requirement established the administrative office and procedures needed to carry out the day-to-day operations of the Requirement, explored the efficacy of various pre-admissions diagnostic writing tests, reviewed information from admissions folders to help understand current writing problems, developed an in-house MIT diagnostic test (with some of the essays read by a board of evaluators), and in other ways tested the effectiveness of various options being considered by the Committee to satisfy the first stage of the Requirement. It also continued efforts to extend the concept of cooperative writing subjects (currently set up in the School of Engineering) to other Schools, especially the School of Science. The Committee reported its progress to the CEP and to the Faculty, including the specific options that will be allowed for satisfying the two stages of the Writing Requirement.

The Committee on the Humanities, Arts, and Social Sciences Requirement, in its final year, confined itself to minimum necessities in administering the HASS Requirement.

Aside from reviewing cases that fell within its jurisdiction, the principal item addressed by the Committee on Outside Professional Activities was to clarify and extend the current guidelines in Section 2.12 of *Policies and Procedures*. The specific changes addressed conflicts of interest that may arise out of sexual relationships, as well as those that can arise from association of MIT's image or name with commercial interests in the public eye.

The Committee on Industrial Liaison reviewed the significant growth in recent years of the MIT Industrial Liaison Program (ILP) and its various activities. The Committee assessed questions about the further development of the Program, especially its ideal size relative to the size of the MIT faculty and the geographical distribution of membership, and concluded that the Program has been developing at a healthy rate in directions which benefit both the Institute and the industrial community. Because of the great importance of the ILP to the Institute's relationship with industry and to the nature and amount of research which originates from the Program, the Committee will continue to follow the ILP activities with great interest.

Sincere appreciation is extended to the following faculty members for their special contributions and service as appointed chairs of the Standing and Special Faculty Committees during the past year: William Kaufmann (Academic Performance), Alvin Drake (Curricula), Chryssostomos Chryssostomidis (Discipline), Steven Lerman (Faculty-Administration), János Beér (Industrial Liaison), William Siebert (Library System), Henry Jacoby (Nominations), Gordon Kaufman (Outside Professional Activities), Campbell Searle (Student Affairs), Sheila Widnall (Undergraduate Admissions and Financial Aid), Robert Bishop (Humanities, Arts, and Social Sciences Requirement), Kenneth Manning (Writing Requirement), Philip Morrison (Killian Faculty Achievement Award Selection Committee), and June Matthews (Edgerton Faculty Achievement Award Selection Committee).

The following retired from the CEP at the end of the 1982-83 academic year: Professors Felix Villars (Chairman of the Faculty), Harvey Sapolsky (Associate Chairman of the Faculty), Sylvain Bromberger, Rae Goodell, Margaret MacVicar, and Kim Vandiver, and student members Steven Isakowitz, Michael Nell, Richard Ross, and James Taylor. Their contributions and dedication are greatly appreciated. Professor Arthur Smith will continue on the CEP in his new role as Chairman of the Faculty.

FELIX M. H. VILLARS
DAVID S. WILEY

School of Architecture and Planning

The relationship between resources and responsibility is a societal concern that we are experiencing in all aspects of our educational life. In our university community, the Institute's planning needs require the School to make rigorous projections that are both tested by intentions and measured by foreseeable resources. This exercise must take place in the context of important but not yet fully explained changes in professional practice: less building volume, a declining share of design responsibility for architects, a shift in the allocation of responsibility and risk in development projects, and the greater numbers of architects and planners.

In the practice of architecture and planning, and especially in preparation for such practice, we direct increasing attention to what we might do better to exercise our responsibility for the human, intellectual, and physical assets that today's society holds as steward for tomorrow. To exercise responsibility, we must first know and convey how the actions we advocate are likely to affect those resources; and secondly we must advocate only those actions we judge likely to enhance those resources.

Regardless of specialty, the designer remains responsible for exploring and predicting the outcome of proposed actions across four broad dimensions: individual well-being, the environment, efficiency, and equity. As educators we must inculcate predictive ability within and across each of these dimensions, attending to the full variety of values present in any place-making task, and encouraging others with relevant knowledge to engage us in the architectural and planning effort. As educators, we must also set aside funds and energy for research that will build new knowledge. Against this array of challenges is the reality of rising educational costs and government cutbacks, which can affect the diversity of our student population and the research opportunities that enhance the quality of our education.

The School continues to attract outstanding students. Total enrollment has stabilized around the level of 500. Women comprise some half of the planning students and one-third of the architecture students. The number of foreign students has increased slightly; the number of planning PhDs is rising. The number of undergraduate planning majors is very small although we continue to have a large number of undergraduates registered in our subjects for their humanities distribution requirements. Behind these indices, however, there is more troubling evidence. For example, this year minority applicants for planning decreased some 50 percent. Further, we are hearing from accepted students who choose other schools that cost is a key element in their decisions.

Financial support for students continues to diminish in volume and availability in both graduate and undergraduate programs. This problem is compounded by the large ratio of debt to earnings experienced by students in the School. With starting salaries for architecture graduates and for MCP and PhD planning graduates at $15,000, $18,000, and $20,000, respectively (compared with $35,000 and more for Sloan School students), our students can face annual loan repayments of the order of 48 percent, 25 percent, and 16 percent, respectively, of earned income.

The current annual level of graduate support provided from all sources to students in the School is $1.5 million. Total annual funds needed from all sources to halve the debt students face are $2.5 million. This disparity is the single most important problem facing the School today and accounts for our sense of urgency about seeking new soucres of aid to alleviate the student debt gap.

Another costly priority is upgrading the School's physical facilities to levels competitive with peer institutions. A report on long-term strategic space planning will be presented to the administration in the coming fall. It will contain overall guidelines to the School's needs in coming years, focusing on how the School can move some of its activities out of the central area of MIT so that more effective use can be made of the space that is available there, including accommodation for a School lecture, exhibit, and social center and a major expansion of Rotch Library.

To meet both education and facility needs, the School must increase its endowment and add anuual giving to its resource base. It has to raise research funding and improve its internship levels. It must also increase the value of the degrees offered by creating new programs and making students more valuable to the profession.

With assistance from MIT's Development Office, the School has embarked on a resource development plan to enlarge the endowment and annual giving base. Steps immediately under way in this planning include improving communications within the School and between the School and its professional community, and raising funds to help support the development campaign itself. As part of these efforts, the first two issues of PLAN, a quarterly School newsletter, appeared this year.

EDUCATIONAL INITIATIVES

Both departments of the School are examining and responding to the financial pressures on their graduates and to the changing demands of their professions. In addition to reviewing and revising their current curriculum offerings, the departments are supporting new programs.

MCP Core

A new curriculum introduced this year by the Department of Urban Studies and Planning integrates theory and method in teaching first-semester MCP students the kinds of knowledge that inform planning decisions.

The core consists of group projects and three subject components--Political Economy for Planners, Quantitative Reasoning, and Planning and Institutional Processes. The first two are descendants of subjects from previous years, while the third is a merger of formerly separate subjects reshaped as a historical treatment of the planning tradition. This year Boston's Copley Place and Blue Hill Avenue development schemes were chosen as case material.

The Department has a faculty team functioning in a sustained way so that, for instance, technical analysis will not be viewed separately but can be seen in the context of other ways of thinking. The new core is one of several ongoing revisions to the MCP program, which include reconsiderations of specialized subject offerings for better coordination with the core and a shift in thesis requirements to allow more class work.

Real Estate Program

Both departments are jointly supporting the design of a new master's program in real estate development. This degree program would provide an interdisciplinary education that draws on existing and new offerings from the Sloan School of Management, the Department of Civil Engineering, and the School of Architecture and Planning.

Concurrent with the development of this new curriculum, the School has established a new Center for Real Estate Development that will bring together business, government, and academic sectors to examine the specific design, management, and policy issues that attend real estate development. The Director, and a major sponsor, of the new center is Charles Spaulding, who recently retired as Chairman of Spaulding and Slye Corporation.

Research Support

The Laboratory of Architecture and Planning is supporting the development needs of the School in several ways, particularly in encouraging a broad research base within the School as well as collaboration with industry, practice, and other universities. One example, in its first year, is the Joint Program for Energy Efficient Buildings and Systems, jointly sponsored by our School, the School of Engineering, and MIT Energy Laboratory. A new School-wide program, based in the LAP, is the East Asian Architecture and Planning Program. The LAP also initiated a program for short-term continuing professional education courses about design and planning issues in developing areas.

The range of LAP offerings is based on a commitment to use research to influence practice. This year the LAP's continuous learning programs brought in 200 professionals from 35 countries. This was the fourth year the LAP hosted the Energy Design Institute of the Association of Collegiate Schools of Architecture. Representatives from almost all the nation's architecture schools have now attended this Institute.

Arts and Media Technology

The Arts and Media Technology building, under construction since last winter on Ames Street, is solid evidence of the energies and resources coalescing around a young area of study at the Institute, which has evolved in good part from thinking and technologies developed in the Department of Architecture's visual studies program. Commencing with the 1983 fall semester, the once discrete departmental disciplines of film, graphics, photography, and computer technology will come together with such other programs as learning research and experimental music to form a new interdisciplinary Media Laboratory in the School.

The Media Laboratory will co-occupy the new building with the Albert and Vera List Visual Arts Center, the Villers Experimental Media Theater, Educational Video Resources, and the Council for the Arts. The Laboratory will have two roles: a research agenda for inventing and using creatively new media

and an academic function that is in itself two-fold--to host the current Master of Science in Visual Studies program and to engage the larger educational functions that would lead to a broader and more robust disciplinary field. At the onset the director of the Laboratory and the degree chair will be the same person and will report respectively to the Dean of the School and to the Head of the Department of Architecture.

Outside funds will be sought to support a program of senior fellows at a level adequate to attract eminent fellows and to support the special training and research assistance needed to insure optimum interaction of fellows with the Laboratory's technological capabilities. Such a program will be particularly effective for engaging the artistic potential of the Laboratory's activities.

The process of devising an administrative structure and configuring the occupancy of the new AMT building stimulated a lot of healthy debate, itself evidence of the energy and imagination of the participation now bounded by the AMT label. This lively and constructive decision-making experience augurs the future success of this new center at MIT.

VISITING COMMITTEE

Development of resources for the future was the theme of the Visiting Committee meeting of the School in December. In attendance were 22 of 28 members, including 10 new members, who examined the School's need to make the best possible use of existing resources, to increase available resources, and to increase the value to recipients of degrees awarded in the School. Exchanges were stimulated by faculty presentations, informal discussions with students, the opportunity to inspect selected School programs, and the review of three prior subcommittee reports on architecture, planning, and arts and media technology programs.

The Committee commended the School for its continuing emphasis on social concerns and, looking to the future, its attention to the pressing need to reshape existing resources and locate new ones in alignment with changes taking place in the university and in the professions. The Committee urged the School to continue to explore using its resources to train students in nontraditional careers and to expand its advanced practitioner programs.

PUBLIC LIFE

The School has long been known for its deep commitment to community involvement in both education and professional practice. Our curriculum emphasizes the importance of field work; our research provides another bridge. For example, we are a major participant in a Boston neighborhood network arrangement to transfer university expertise to the neighborhood level. More recently we have undertaken the direction of the principal staff work for the Copley Centennial Committee, a major effort to redesign Boston's historic Copley Square.

In the past year School members have also contributed to public life through government consulting in this country and abroad, public appearances, books, articles, film, video, and legislative testimony. This year our faculty were particularly remarked for political engagement. Professor Melvin King became a candidate for the position of Mayor of Boston. And Governor Michael Dukakis of Massachusetts appointed two faculty members to positions in his new administration: Professor Tunney Lee as head of the state's Division of Capital Planning and Operations, and Professor Langley Keyes as special assistant for policy development in the Executive Office of Communities and Development.

JOHN de MONCHAUX

STUDENT ENROLLMENT AND COMPOSITION 1982-83

Department of Architecture	Total	Women	%Women	Minority	%Minority	Foreign	%Foreign
Undergraduate	72	22	31%	4	6%	7	10%
M.Arch.	103	39	38%	9	9%	5	5%
S.M.Arch.S.	73	19	26%	1	1%	55	75%
S.M.Vis.S.	42	13	31%	3	7%	2	5%
Ph.D. (resident)	15	4	27%	0	0%	7	47%
Special Students	7	3	43%	0	0%	1	14%
Jt. M.Arch./M.C.P.*	0	0	0%	0	0%	0	0%
Jt. S.M.Arch.S./M.C.P.*	5	3	60%	1	20%	3	60%
Architecture Totals	317	103	32%	18	6%	80	25%
Department of Urban Studies and Planning							
Undergraduate	9	5	56%	2	22%	0	0%
M.C.P.	70	42	60%	15	21%	7	10%
Ph.D. (resident)	49	24	49%	5	10%	24	49%
Jt. M.C.P./M.Arch.	5	2	40%	1	20%	1	20%
Special Students**							
SPURS***	13	2	15%	0	0%	13	100%
CFP***	11	8	73%	11	100%	0	0%
DUSP Totals	157	83	53%	34	22%	45	29%
School							
Undergraduates	81	27	33%	6	7%	7	9%
Graduate	362	146	40%	35	10%	104	29%
Special Students	31	13	42%	11	35%	14	45%
TOTAL ENROLLMENT	474	186	39%	52	11%	125	26%

* Joint degree students are also counted in the degree programs in which they registered.
** Non-degree candidates.
*** Special non-degree programs in the Department of Urban Studies and Planning: the Special Program for Urban and Regional Studies of Developing Countries (SPURS), begun in 1967; and the Community Fellows Program (CFP), established in 1971.

FACULTY, OTHER ACADEMIC STAFF, AND RESEARCH STAFF -- 1980-81, 1981-82, 1982-83

	Total	E.F.T.	Women	Minority	Total	E.F.T.	Women	Minority	Total	E.F.T.	Women	Minority
	1980-81				1981-82				1982-83			
Architecture												
Faculty	35	31.3	6	2	34	28.5	4	1	34	28	3	1
Other Academic Staff	54	19.5	15	2	59	25	14	1	41	21	6	-
Research Staff	9	6.5	1	-	7	6.5	-	-	8	8	-	-
Without Pay	11	7	4	-	14	10	3	-	7	-	2	-
DUSP												
Faculty	32	26.33	4	5	28	23.5	4	4	27	24.5	5	4
Other Academic Staff	9	5	1	3	16	6.25	1	3	12	5.8	3	2
Research Staff	1	0.25	1	-	3	2.2	-	-	-	-	-	-
Without Pay	2	-	-	-	6	-	-	1	15	-	-	1
Laboratory of Architecture and Planning												
Faculty	-	-	-	-	-	-	-	-	-	-	-	-
Other Academic Staff	2	2	-	-	2	2	-	-	2	2	-	-
Research Staff	11	5.3	7	-	8	4	5	-	9	8	6	-
Without Pay	9	4.15	3	-	11	8	5	-	7	5	2	-
SCHOOL TOTALS												
Faculty	67	57.63	10	7	62	52	8	5	61	52.5	8	5
Other Academic Staff	65	26.5	16	5	77	33.25	15	4	55	28.8	9	2
Research Staff	21	12.05	9	-	18	12.7	5	-	17	16	6	-
Without Pay	22	11.15	7	-	31	18	8	1	29	5	4	1

Department of Architecture

As John Myer began as Department Head this year, changes within the Department, in academic financing, and in the world of practice our graduates will enter suggested that the Department undertake some review of its programs.

While the central task of architecture remains in formmaking -- the artful making of buildings and places -- architectural practice is in a state of considerable change. Problems to be addressed are increasingly complex, requiring understanding and response to interdependent issues of economics, politics, technology, and ecology. The client to be served is more often now a multiple or bureaucratized one. Technology is providing new tools which need to be understood. In particular, the use of computer drafting machines in practice is changing the mode of delivering services and will affect in a critical way the number and kinds of jobs our graduates will find.

Further, the high cost of architectural education versus the low starting salaries in the profession may limit our ability to attract students to architecture. Our professional program will need to be responsive to these changes and demands in order to continue attracting and training first-rate students.

We therefore focussed attention this year on the Master of Architecture (MArch) program and its relation to practice. Following on the agenda-building led by Professor Julian Beinart last year, three committees were formed to examine the curriculum from different perspectives: first, a committee of design faculty charged to study architectural design studio teaching; second, a committee to examine the MArch curriculum; and third, a committee to study the profession, its future, and implications for our curriculum. A synthesis of their recommendations will form the basis for changes in the MArch program in the coming years.

While the MArch program has been a principal focus of study, several other important factors causing change in the Department and School demanded attention.

Rising tuition costs and the unfavorable cost/price ratio of professional education in both architecture and planning have intensified the need to increase our resources to provide financial support for students. A School-wide development effort, led by Dean John de Monchaux, will increase our outreach to alumni/ae and the professional community. Among the several items in need of funding -- new programs, upgrading of space -- scholarship support is of the highest priority.

Budget-cutting, now in the second of a three-year schedule required by the Institute, has led to serious reconsideration of all Department programs. We are pressed to be increasingly inventive in our use of resources in order to enable curriculum changes and allow for new initiatives.

One initiative has come from the Department of Urban Studies and Planning (DUSP) in planning a master's degree in real estate development. A School committee has prepared a proposal which will be submitted for Institute approval for a curriculum composed of subjects in Architecture, DUSP, and other Institute departments. The establishment of such a program at MIT, one of the first to be set within a school of architecture and planning, seems both timely and appropriate.

Another important cooperative effort has been in development of plans for a School computer resource laboratory. Professors Gary Hack (DUSP) and John Myer, together with members of the School Council and other faculty, have moved to acquire space, equipment, and funding for a microcomputer facility intended to be operational in the next academic year.

With the completion of the new Arts and Media Technology (AMT) building anticipated in the fall of 1984, the Department's AMT activities have also been in the process of change. The Task Force named last year to develop a framework for the program (Institute Professor Jerome B. Wiesner, Professors Beinart, Nicholas Negroponte, Myer, Dean de Monchaux, chair) has proposed that AMT offerings be included in a Media Laboratory, to remain for the time being within the Department. Since the Laboratory will bear major responsibility for the S.M. Visual Studies (SMVisS) degree offering, its relationship to Department teaching and governance has been the subject of discussion throughout the year.

Finally, important shifts in core faculty and heightening interest in teaching and research in the fields of developing countries and international practice suggested the value of restudying the S.M. in Architecture Studies (SMArchS) degree program. Professor John Habraken chaired a committee whose activities are described under the S.M. Architecture Studies heading below.

All of the foregoing issues and concerns are closely interrelated. In this broad study program of all elements of the Department, we are seeking to bring new energy to our already strong programs.

PROGRAMS

The Department had a total of 305 students enrolled as regular students in its five degree programs in 1982-83. Ph.D. (15), SMArchS (73), SMVisS (42), MArch (103), and SBAD (72). Of the total student population, 32 percent are women, four percent are minority, 24 percent are international students. The number of applicants to all Department programs for fall 1983 remained relatively stable at 543.

Master of Architecture (MArch)

The MArch program was the subject of study for three committees this year. The first, comprising design studio faculty, chaired by Professors Jan Wampler and Robert Slattery, focussed discussion on architectural design studio teaching -- particularly coordination of the sequence of the studio experience, visiting faculty contribution, and articulation of a shared theoretical base of Department design teaching. Members of the committee were Professors Maurice Smith, Shun Kanda, Fernando Domeyko, and Richard Tremaglio. They have put forward a revised format for the design sequence, and a group of faculty will develop the first piece -- a foundation subject taught as the first studio -- to be offered in fall 1983.

A second committee, chaired by Professor William Porter, was composed of Professors Stanford Anderson, Eric Dluhosch, Leon Groisser, Slattery, Smith, Chester Sprague, and Myer, and three student representatives, Barbara Thornton, David Nelson, and Keith Giamportone. Operating under a charge from the Department Head to review, criticize, and project anew the direction of the professional curriculum, the committee considered the particular identity of MIT's Architecture Department with respect to other American schools of architecture, the Department's role within MIT, the balance in curriculum between theory and practice, and between focus on design and specialization in other related areas. Its recommendations are expected to generate activities in the coming year which will give rise to substantial changes in the total MArch curriculum.

A third committee, chaired by Bruce Anderson (MArch 1973 and member of the Department's Visiting Committee) centered its attention on the future of the architectural profession. Faculty from Architecture, DUSP, Civil Engineering, alumni/ae, and students participated in weekly seminar sessions during the spring term. Their report is expected to set a context for architectural education and to inform decisions made on curriculum change proposed by the studio faculty and the MArch curriculum committees.

The number of applications for the MArch program continued to be high, and a larger number of design faculty were involved this year in our very intensive admissions process. Professors Kanda, Myer, Slattery, Smith, Sprague, and Wampler did the first round reading; final reading and admission was done by Professors Groisser, Slattery, Smith, Sprague, and six graduate MArch students. For 1983-84, there were 281 applicants for 28 places.

Speakers in the MArch weekly lecture series this year included Julian Poesner, architectural historian, Kenneth Frampton, historian and critic, and architects Gottfried Boehm and Juan Downey, among others.

Awards to graduating MArch students were as follows: American Institute of Architects (AIA) Medal to Benjamin Wood, the Alpha Rho Chi Medal to Marilys Nepomechie, AIA Certificate to Bradford Edgerly, the Chandler Prize to Peter Haig and Steven Lovell, the Chamberlain Prize to Judith Dayton and Craig Whitaker.

S.M. Architecture Studies (SMArchS)

The Department's postprofessional program, S.M. Architecture Studies, continued to grow, enrolling 73 students in fall 1983 into four areas of concentration: Housing and Settlement Design; Building Technology; Environmental Design; and History, Theory, and Criticism. 75 percent of the students are international. Professor Habraken was chairman of the degree program.

Professor Habraken also chaired a committee of SMArchS core faculty to study the program and make recommendations for revision in response to important changes. Shifts in senior faculty encouraged reorganization among program groups: the expected retirement of Professor Horacio Caminos in 1984 as director of the Settlement Design section, the departure of Professors Hack and Myer from the Environmental Design group to become department heads in DUSP and Architecture, and the addition to the faculty of Professor William Porter, also director of the Aga Khan program. Further, increasing interest in the program's ongoing teaching and research in developing countries and international practice suggested the value of new collaborations among program components and links to work being done in other School and Institute groups -- the Aga Khan program, DUSP, and others. Professor Habraken's committee is expected to to make a proposal in fall 1983 to restructure the program's governance, admissions, and curriculum.

Special events in SMArchS included a seminar and workshop sessions, "Design and Housing in Developing Countries," held at MIT in August. The meeting, offered as part of the Laboratory of Architecture and Planning (LAP)'s newly formed Professional Practice Program, drew together experts in the field of third world housing. It was organized by Professor Nabeel Hamdi and Mr. Reinhard Goethert.

In September, a reunion was held to mark the 15th anniversary of the Housing and Settlement Design Program. Approximately 50 graduates representing education, practice, and government gathered for the event. A scholarship fund was established in honor of Professor Caminos, the program's founder, and Mr. Goethert, who has been with the program since 1968. In addition, an association of alumni was formed at the meeting which will seek to encourage and support architecture education directed toward housing in developing countries.

Two programs which involved Department students in the conduct of research were based in the SMArchS program. First, the Research Incentive program, now in its second year, awarded funding for research assistants to a number of projects. Support was made possible by a grant from the Ernest A. Grunsfeld fund, with matching funds from MIT. Projects included: a study of potential use of LANDSAT imagery in urban studies, Mr. Goethert, director; a study of the urban tissue in Bath, England, Professor Hamdi, director; and a study of the Orient Heights, Boston housing project, Professor Hamdi, director.

The "Research for Credit" program, in its first full year, involved SMArchS and MArch students in projects for academic credit. Among topics offered were "Rapid Uncontrolled Urban Population Growth: American Analogs with Developing Countries," and "An Interactive Microcomputer Training Tool for Design: Analysis of Housing Sites."

S.M. Visual Studies (SMVisS)

The S.M. Visual Studies program had an enrollment of 42 students in its five member groups, the Architecture Machine Group, Visible Language Workshop (VLW), Center for Advanced Visual Studies (CAVS), Film/Video, and the Creative Photography Laboratory. Program faculty, together with other Institute groups and the AMT Task Force, worked to develop further a shared intellectual and artistic agenda for the emerging AMT program.

Subject offerings in the degree program expanded into the field of spatial imaging/holography. Professor Stephen Benton, Polaroid Corp., under a joint appointment in Architecture and Electrical Engineering, taught two new subjects in holographic imaging at the Creative Photography Laboratory.

In response to programmatic and financial concerns, the decision was made to discontinue the graduate concentration of the SMVisS degree in creative photography. Teaching of undergraduate photography subjects will be continued under the direction of the VLW.

The VLW's programs were enhanced by gifts of equipment from Compugraphic and Linotype Paul, which will be interfaced with the VLW system to investigate new possibilities for generation of type and images. Continuing donations of equipment and materials from Polaroid Corp. provided crucial support for research, class, and exhibition projects.

Five shows were supported at the VLW Gallery by grants from MIT's Council for the Arts and Polaroid Corp. In addition, VLW faculty and student computer graphic work was shown in the SIGGRAPH '82 Art Show in Boston, at the Minneapolis College of Art and Design Gallery, and in an exhibit at the American Institute of Graphic Arts, New York. Eleven images by VLW artists were chosen for a special Digital Portfolio project by Computer Graphics World Magazine, to appear in August 1983. In January, the Workshop hosted a conference, TRANSMIT, to examine the art and technology of old and new transmission media. The conference included a live slow-scan video and electronic music performance between the VLW and the School of the Art Institute of Chicago and was supported by a grant from the MIT Council for the Arts.

Two important awards were received by the Film/Video group. First, a gift of video recording and editing equipment from the Ampex Corporation, which has been incorporated into Film/Video's editing lab, will further the group's explorations of new personal approaches to computer-aided video editing and research into new movie forms and imaging techniques. Second, a grant from the National Endowment for the Arts will support a three year project for filming the documentary "New Orleans in Transition." Co-directors, Professor Ricky Leacock and Ms. Glorianna Davenport, will record effects on New Orleans of planning and changes for the World's Fair in 1984.

The Film/Video section's Monday night screening series, in the second of a three-year grant from the Louis B. Mayer Foundation, featured a number of filmmakers who presented their work to large audiences for the MIT community. Again this year, work by graduates, graduate students, and faculty of the Film/Video section were shown in a number of national and international film festivals.

Ph.D.

Though most PhD candidates have been in the History, Theory, and Criticism (HTC) area, the gradual expansion into other areas has continued. Two PhD candidates studied in the Architecture Machine Group and three in the Housing Design section. PhD enrollment totalled 21 resident and nonresident students, and applications for places in 1983 rose to 42 from 30 the previous year. Professor Stanford Anderson chaired the PhD committee.

A number of conferences in which PhD candidates participated were organized by the HTC group. In November, an international conference on architecture and urbanism in the Netherlands between the two World Wars brought together 20 scholars from MIT and other American and Dutch universities for three days of sessions. Alison Smithson, British architect and theorist, gave public lectures and seminars on Team Ten at MIT in February. A single-session symposium on Beaux Arts theory and practice and its transmission to American practice was offered in May.

A schedule of public lectures on history of art topics was presented, and 10 sessions of the PhD Forum offered opportunities for exchange on a visiting scholar or professional's recent work.

RESEARCH

Funded research in the Department of Architecture totalled $1.5 million. Funding for projects in the Architecture Machine Group was $1.2 million; the balance of Department research, administered through the Laboratory for Architecture and Planning, was approximately $340,000.

Research in the Architecture Machine Group was centered in the general domain of media technology and computationally augmented communication. Funded projects included: "Movie Manuals," which developed the notion of an electronic book; "Transmission of Presence," which emphasized three-dimensional interaction and shared graphical work spaces. New work included development of computational telephones, under a contract from the Atari Corporation, and initial work on a "Graphical Marionette," under a contract from NHK (Japanese Broadcasting Corporation).

All other research for which Department faculty were principal investigators is described in the report of the Laboratory of Architecture and Planning.

FACULTY

Professor Myer began as Department Head on September 1, 1982. He has been a member of the Department faculty since 1959 and is president of the Cambridge architectural firm, Arrowstreet, Inc.

New appointments to the faculty: in HTC, Kurt Forster, Professor of the History of Architecture, and Yasser Tabbaa, Aga Khan Development Professor in the History of Islamic Architecture. In SMVisS, Stephen Benton was appointed Associate Professor of Computer Graphics, and Jean-Pierre Beauviala, Visiting Professor in Film/Video. Ranko Bon was appointed Lecturer in the SMArchS program in spring term; he will begin next fall as Assistant Professor of Economics in Architecture.

There were also a number of visiting appointments: Bruce Anderson, Lecturer; Renee Chow (MArch 1977), Norris Strawbridge (MArch 1976), Daphne Petrie (MArch 1976), and Kyu Sung Woo as design instructors, fall term. William Wright, Lecturer in Building Technology; Judith McDonough and Robert Horvitz, Lecturers in HTC, fall term. Graham Brawn, Visiting Professor in Environmental Design, SMArchS, spring term. Visiting Professors Gottfried Boehm, Institute of Technology, Aachen, Germany, and Gerhard Kallmann, Professor Emeritus, Harvard University, taught Level III architectural design studios in the spring term.

On leave were Professor Beinart (fall), after serving last year as Interim Department Head; Professor Nicholas Negroponte, to head the World Center for Microcomputer Science and Human Resources in Paris; Professor Robert Preusser (fall); and Professor David Friedman (spring).

Faculty serving as journal editors were: Professor Beinart, with Professor Giancarlo De Carlo, assisted by Professor Edward Robbins, Space and Society, MIT Press (fall); Professor Preusser, the graphic arts journal, Leonardo; Professor Hamdi, co-editor, an edition of Open House.

Special note should be made of an award in honor of Professor Emeritus Gyorgy Kepes, founder of the Center for Advanced Visual Studies. At its annual meeting in November, the MIT Council for the Arts announced endowment of the Gyorgy Kepes Fellowship Prize to be awarded annually to a creative individual who has "demonstrated a concern for human values as reflected in the relationships between art and the environment."

Professor Muriel Cooper received the First Distinguished Graduate award from the Massachusetts College of Art in May 1983.

Professor Edward Allen has submitted his resignation, effective in June 1983, to return to full-time architectural practice.

JOHN R. MYER

Department of Urban Studies and Planning

INTRODUCTION

This was a year of assessing the Department's strengths and weaknesses, and the need to change in response to a shifting context in the Institute and in urban areas.

On the educational side, attracting undergraduate majors continued to be problematic, despite curriculum changes and a change in name to Bachelor of Science in Planning. Instituting a new core program for our professional master's degree commmanded much of our energy and attention. The faculty agreed on the desirability of expanding our master's enrollments by providing a new developing areas option, and curriculum development was begun. Proposals were advanced for two new specialized S.M. programs: in real estate development (to be offered on a school-wide basis) and in urban operations planning and management (a joint effort with the Operations Research Center and other departments). And discussions of our Ph.D. program led to changes in requirements and a commitment to do a major reassessment during the coming year.

Faculty were engaged in a number of ground-breaking research projects, although overall research volume was low. We have been slow to adapt to the changing nature of research sponsorship -- drastic reductions in Federal support, more contracts and fewer grants, and less foundation interest in the areas. Future years will require major investments in assembling new sources of funding for research.

Through a series of symposia, conferences, and public lectures, the Department reestablished ties to the community of planning practitioners and alumni in the Boston area.

UNDERGRADUATE PROGRAM

The vast majority of students enrolled in Course XI undergraduate subjects are, again this year, taking them as unrestricted electives or as part of their humanities, arts and social sciences requirement. Enrollment in the Department's humanities distribution subjects also remain high and the number of students selecting sequences in the Department for their concentration has remained steady.

However, the number of undergraduate majors remains small, consistent with the trend of Institute undergraduates towards majoring in a few engineering fields. The Department has responded by emphasizing teaching for those who pursue urban studies as a concentration, or as a way of providing an area of application for students from other fields. We are now combining graduate and undergraduate subjects having similar topics and are creating separate tutorials for graduates and undergraduates within those subjects.

Professor Aaron Fleisher directed the undergraduate program this year.

PROFESSIONAL DEGREE PROGRAM

The fall semester marked the introduction of a revised core curriculum developed by the Department over the last two years. The new core integrates theory and method in a refocused approach to teaching the kinds of knowledge required for planning. The core curriculum is the result of a year and a half of planning by a Department committee that included Professors Donald Schon, Langley Keyes, Tunney Lee, Mark Schuster, and Bennett Harrisson, as well as students. The committee's work produced the ideas basic to the new core: that it should be grounded in a common set of cases and that it should coordinate required subject material, assignments, and projects so that they constitute a single experience. The five faculty on the committee became the teachers of the core subjects.

In its final version, the core consisted of three subject components -- Political Economy for Planners, Quantitative Reasoning, and Planning and Institutional Processes -- as well as group projects involving students and faculty. Boston's Copley Place and the Blue Hill Corridor were chosen as case material and project settings, respectively.

The new core is one of several ongoing revisions to the professional degree program. Faculty also reconsidered specialized subject offerings for better coordination with the core and continued the experiment of allowing smaller-scaled theses to allow more students to invest more time in taking specialized subjects.

At the end of the academic year, the MCP Committee and the faculty endorsed the proposal to increase enrollments in the program by 10 to 15 students per year through creating a new developing areas option. Details remain to be worked out and agreement will be sought to allow the option to begin in fall 1984.

DOCTORAL PROGRAM

We have decided upon several changes to our Ph.D. program, in response to student suggestions and to faculty concern regarding the direction of the program. During academic year 1983-84, the Department will have at least six semester-long seminars on a range of topics aimed at Ph.D. students, and at broadening intellectual opportunities. All students who have not completed their general exams will be expected to take one seminar each year. We will also have bi-weekly research colloquia, and on alternate weeks a first-year seminar and a dissertation seminar will be conducted. Other adjustments were made to requirements as an interim step. We have also convened a study group to look at the long-term direction of our Ph.D. program and a report is expected by spring 1983. Professor Susskind has agreed to chair this group and will take over as head of the Ph.D. Committee during 1983-84. Professor Robert Fogelson continued to serve as head of the Ph.D. Committee this year.

SPURS (Special Program for Urban and Regional Studies)

There were 13 Fellows in the SPURS program for the 1982-83 academic year; three from India, two from Taiwan, and one each from Japan, Bangladesh, Egypt, Honduras, Mexico, Colombia, Ecuador, and Guyana. Eight of the Fellows were from the public sector, three were from the private sector, and two were professors. The academic background of the Fellows reflected a wide range of disciplines: five in architecture, two in economics, two in sociology, and one each in business, urban planning, social studies, and engineering.

Seven Fellows are returning directly to their countries to take up their previous positions. Two Fellows will continue in the SPURS program next year, and four Fellows are considering going on to various degree programs in the US. Of these, one Fellow has been admitted to the Department's MCP Program.

Three visiting scholars were associated with the SPURS program during the 1982-83 academic year. Leopold Veuve, Professor of Architecture and Planning at the Swiss Federal Institute of Technology at Lausanne, a specialist in decision making in the developing world; Qing Wu, Professor of English at the Beijing Institute of Foreign Languages of the People's Republic of China, an English teacher involved in compiling English tests and readings; and Professor Clyde Weaver of the University of British Columbia, working on a book about regional development.

Professor Rodwin returned from his sabbatical leave and resumed his post as the Director of the program. Among other SPURS faculty, Professor Gakenheimer was on leave in the spring semester at the Institut d'Urbanisme of the University of Paris, exchanging places with Professor Remy Prud'homme of the Institut d'Urbanisme who taught subjects here on planning in developing countries. Professor Peattie was also on partial leave during the spring semester while she worked on a new book on settlement design. Professor Raaj Sah decided to return to teaching and research in the Department of Economics at the University of Pennsylvania. The search for a new development economist to fill that position was not successful and will be continued during the next academic year.

This year's luncheon seminar series included as speakers Professors Paul Samuelson, Arnoldo Hax, Jay Forrester, and Alan Altshuler, of MIT; Dr. Gennady Filshin of the Institute of Economics and Organization of Industrial Production, Siberian Branch of the U.S.S.R. Academy of Sciences, Novosibirsk; Professor Manuel Castells of the University of California at Berkeley; Professor Moshe Safdie, Director of the Urban Design Program, Harvard University; and Professor Thomas Schelling of the Kennedy School of Government, Harvard University.

COMMUNITY FELLOWS

There were 11 Fellows in the Community Fellows Program for the 1982-83 academic year; two from Washington, D.C., one from Phoenix, seven from the New England region, and one from the Anishnabe Indian Reservation in Minnesota. Four of the Fellows specialize in media and telecommunications technology, two are trained in the mental health field, and one is a development planner for American Indian reservations. Other Fellows represent the ministry as well as the legal and artistic professions. The projects which these individuals worked on during the year ranged from research on media ownership and policy to youth development and technological literacy.

While 1983 may have been the most satisfying year for the program, it also marked a significant transition. The program began in 1971 and was conceived as a mid-career opportunity for minority individuals interested in community development in the United States--individuals whose educational objectives could best be met outside of a formal degree program. Initial funding was secured from the Rockefeller and Mellon Foundations, and a host of smaller grants have helped support the program in its middle years. But such support has dried up and the Institute has absorbed all the costs in recent years. Continued

existence of the Community Fellows Program now depends on identifying a new funding base. We are targeting our efforts on identifying local businesses, corporations, and foundations in cities around the country which are willing to sponsor a Fellow from their city to attend MIT. During 1983-84, the program will be suspended while these sponsors are sought.

POSTDOCTORAL PROGRAM

Two postdoctoral fellows joined the department for research and teaching. Dr. Dorothy Robyn spent the year refining her dissertation research which examines the political battle for trucking deregulation. She also taught a graduate-level subject on methods of public policy analysis. Dr. Julia Trilling developed with Professor John de Monchaux a new course on comparative perspectives on urban settlement design. She also assisted Professors Hack and Porter in their introductory Urban Design subject and led a seminar for advanced students on the cultural history of the American landscape.

FACULTY

Gary A. Hack, Associate Professor of Urban Design, became head of the Department in August, 1982. He was first appointed to the MIT faculty in 1971 and taught at the Institute until 1975. From 1975 to 1978 he was general manager for research and demonstration programs of the Canadian government's housing and urban affairs agencies, returning to MIT as an associate professor in 1978. He has headed the joint program in Environmental Design of the Departments of Urban Studies and Planning, and Architecture.

Lawrence E. Susskind was promoted to full professor during the year. Professor Susskind served as Department Head from 1978-82 and during the past year was on professional leave as Acting Executive Director of the Center for Negotiation at Harvard Law School.

Bennett Harrison was also promoted to full professor this year. His most recent book (with Barry Bluestone), the Deindustrialization of America, was published in September of this year and attracted considerable note in the debate over national industrial policies. During the spring semester, Professor Harrison was on leave teaching at the University of California, Berkeley, and University of Venice.

Four new faculty were added to the Department's teaching staff. Lynne B. Sagalyn was appointed Assistant Professor of Planning and Real Estate Development. A former fellow at both MIT and the Joint Center for Urban Studies of MIT and Harvard, she is the author of a book and several articles on housing, finance, and neighborhood development. Her present research, being done jointly with Professor Bernard Frieden, focuses on public/private relationships in the rebuilding of downtown areas. She taught subjects in real estate finance.

Merrie Klapp, formerly a lecturer at the University of Santa Cruz and at Stanford University, joined the faculty as Assistant Professor of Environmental Studies and Planning. Her recent work has focused on the conflict over the use of off-shore territory by oil, shipping, and fishing interests, especially in the North Sea and South China Sea regions. She taught subjects on environmental quality issues.

Yohel Camayd-Freixas was named Assistant Professor of Planning and Community Psychology. He is also the Associate Director of the Community Fellows Program. Professor Camayd-Freixas obtained his doctorate from Boston College in 1982 and has served as Director of the Jamaica Plain Outreach Program under the Mass. Mental Health Center. He has also served as Clinical Supervisor of the Minority Psychology Training Program at Boston City Hospital. His research focuses on social inequality among racial/ethnic groups (including women) and emphasizes status acquisition processes, social mobility, and political participation. He taught subjects on networks in communities.

Belden Daniels, a lawyer and former international banker, served as lecturer in development finance in the neighborhood and community development area. He is President of the Council for Community Development, Inc., a firm specializing in development finance and economic development in the United States and abroad and has taught development finance at Harvard.

Two of our faculty were granted leaves during the year to serve in key positions in the Dukakis administration of the Commonwealth. Professor Langley Keyes is now Special Assistant for Policy Development in the Executive Office of Communities and Development. He has particular responsibility for policy on the the problems of homeless, and continues to teach part-time at MIT. Professor Tunney Lee is now head of the Department of Capital Planning and Operations, the Commonwealth's building and land management agency. Professor Lee's responsibilities include the design and construction of state buildings, leasing of all state facilities, and acquisition and disposition of all state lands.

Several of our faculty participated in activities of considerable note. Among them: Lawrence Bacow, Associate Professor of Law and Environmental Policy, appeared in WGBH-TV's "Nova" series, "Asbestos: A Lethal Legacy," discussing manufacturers' liability for asbestos-related diseases. Professor Bacow has taken on responsibility as faculty coordinator of the proposed new Program in Real Estate Development.

Professor Camayd-Freixas received a Certificate of Recognition for Excellence in Research from PsiChi, the National Honor Society in Psychology, for his paper, "The Costs of Opportunity: Racial-Ethnic Differences in the Psychological Consequences of Successful Status Acquisition," a paper delivered at the Eastern Psychological Association meeting in Philadelphia.

Professor Philip Clay was coauthor of a major study on housing in the US to be released by the Harvard-MIT Joint Center for Urban Studies in the near future. He also completed work on his book, Neighborhood Politics and Planning.

Professor Gakenheimer consulted on the development of a national urban policy for Indonesia, and advised on the development of transportation research at the Institute of Technology, Bandung. During the remainder of the year he was on leave at the Institut d'Urbanisme de Paris, Université de Paris, teaching transportation planning and conducting research on developing countries.

Adjunct Professor Mel King will be a candidate for Mayor of Boston this year. Professor King, who directs the Community Fellows program, has taught at MIT since 1971 and has completed five terms as state representative.

Lisa Peattie, Professor of Urban Anthropology, lectured at the University of Hong Kong during January 1983. Her book, Thinking About Development, was published during the year; and Making Work, with William Ronco, is nearing completion.

Professor Martin Rein was a guest at the Center for Interdisciplinary Research at the University of Bielefeld in West Germany, where he and fifteen other scholars from around the world concentrated on the problems of guidance, control, and evaluation in the public sector. Professor Rein also received the Einstein Fellowship to continue his research in Israel.

Donald Schon, Ford Professor of Urban Studies, gave the keynote address for the annual conference of the Royal Institute of British Architects in July 1982. His talk examined the special nature of architectural education. Professor Schon's book, The Reflective Practitioner, was published in January of this year.

Mark Davidson Schuster, Lecturer in Urban Studies and Planning, is coauthor, with Michael O'Hare, of Patrons Despite Themselves: Taxpayers and Arts Policy, a study sponsored by the Twentieth Century Fund to be published by New York University Press in June 1983.

The search for a faculty member to replace Professor Hack in the Environmental Design area resulted in the hiring of Dennis Frenchman who will hold the title of lecturer. Dr. Frenchman is an architect and planner who practices urban design and is the receipient of several awards during the last six years; among these are the New York State Cultural Park System Award and a reward for his work on the West Broadway Housing Renewal Project in New York.

Kevin Lynch, professor emeritus of city planning, received an honorary doctor of laws degree from Ball State University on April 30 at the dedication of new facilities for the University's College of Architecture and Planning.

In addition to the faculty changes, Susan Smith became Assistant to the Department Head and Director of Program Development for the Department.

RESEARCH

Department faculty were principal investigators on research projects in the school totaling $350,000, with additional projects at the Harvard-MIT Joint Center for Urban Studies and other laboratories or centers.

Professor Gakenheimer continued his efforts on urban infrastructure planning for secondary cities in Egypt through the auspices of the Technology Adaptation Program.

Professor Merrie Klapp was principal investigator of research, sponsored by Westinghouse Electric Corporation, to perform a technical review and evaluation of the quality of research and modeling for ocean disposal of defueled submarine propulsion plants.

Professor Karen Polenske continued on MRIO accounts, under sponsorship of the US Department of Health and Human Services. She also headed a project, part of a multistate effort coordinated by the University of Colorado, assessing the condition of Massachusetts infrastructure and the state's fiscal ability to meet these needs through the year 2000.

Professors Susskind and Keyes continued their program on the impact of Proposition 2 1/2 on local governments and social service agencies. The program was funded by a number of foundations. Professor

Susskind also received two-year funding from a private foundation for the Environmental Negotiation Program, a project which explores techniques for mediating environmental disputes.

Professor Frieden received funding from a private foundation to prepare case studies on current practices in the development of retail and mixed-use developments in downtown locations. This work, directed jointly by Professor Sagalyn, will provide the basis for a new subject to be taught next year, as well as a forthcoming book.

Professor Frank Jones secured support for two-year fellowships for minority students to intern in field agencies as a way of examining the effectiveness with which communities use their block grants; particularly in furthering espoused socioeconomic objectives. The US Department of Housing and Urban Development is the sponsor.

Professor Hack is principal investigator on a field research project aimed at reprogramming Copley Square in Boston. Sponsored by the Copley Square Centennial Committee, a public/private partnership, the project will include a new public design competition and a public awareness campaign. Thomas Piper, Research Associate of the Laboratory of Architecture and Planning, is the project manager.

Professor Schon is principal investigator for a design research project sponsored by the Design Arts Program of the National Endowment for the Arts. Other participants in this project include Professors Hack, Fleisher, Stanford Anderson (Architecture), John Habraken (Architecture), Edward Robbins (Architecture), and Lawrence Buccarelli (Civil Engineering). The study examines the internal processes which designers use to resolve complex situations and produce proposals. The research model looks at how well-known designers have used and transformed ideas through the course of their careers, how design occurs in a group context, and how information is transmitted from master to student. The results from this study will be presented at a conference in January 1984.

CONFERENCES

On January 24, the Department and the Bank of New England cosponsored a daylong conference on "The Community Impacts of the Restructuring of Financial Markets." Initiated by Professor Daniels, this discussion focused on the rise of interstate, less regulated financial institutions; the removal of ceilings on deposit interest rates; and the blurring of distinctions among commercial banks, thrift institutions, and other institutions. The essential question was the impact on community investments. Panelists included Gerald Mulligan, Vice President of Mutual Bank and former Banking Commissioner for the Commonwealth of Massachusetts; Wallace Sellars, Vice President of Merrill Lynch; Congressman Barney Frank; Mary Houghton, Executive Vice President of South Shore Bank in Chicago; and Richard Driscoll, Executive Vice President, Bank of New England. The conference was attended by 180 from financial institutions, public agencies, community organizations and the academic world.

As a spinoff of the banking conference, Mr. Robert Harding of the Bank of New England supervised 15 students as they developed financial models for community development corporations and conducted research on incubator projects now sponsored by the Bank.

More than 250 architects, planners, housing officials, public housing tenants, community organizers, students, and faculty attended the Department's conference in January on public housing modernization, "New Lives for Old Projects." Gordon King, Research Associate in the Laboratory of Architecture and Planning, and Professor Lee organized the daylong event focused on four public housing revitalization projects in Boston and Cambridge. Panelists and workshop leaders reviewed issues of planning, administration cost, financial strategies, design and construction, and tenant participation.

The Sunbelt Cities Conference held during January brought together three distinguished planning professionals from fast growing sunbelt areas to discuss the challenges and opportunities for planning in the southwestern United States. Speakers, all alumni of the Department, included E. Jack Schoop, currently Director of Planning for Santa Clara County in California; Calvin Hamilton, Director of Planning for the City of Los Angeles; and Samuel J. Cullers, formerly Director of State Planning for the State of California.

Edward J. Logue, development director of Boston from 1960 to 1967 and now president of the South Bronx Development Organization, Inc., lectured to a large audience at MIT on April 25 and 26. Mr. Logue reflected about Boston's major redevelopment projects and assessed his more recent efforts in the South Bronx. He described the political partnerships in the development process and examined the broader conditions necessary to transform distressed urban areas into viable urban communities. The lectures were organized by Professor Jones and sponsored in part by the CIGNA Corporation.

Professor Polenske organized a one-day workshop attended by more than 50 academic and public officials on capital budgeting techniques and their relevance to the problem of deteriorating infrastructure. Panelists included David Grossman, President of the Nova Institute; S. Kenneth Howard, Executive Director, Advisory Commission on Intergovernmental Relations in Washington, D.C.; Mark S. Ferber, Public

Finance Department, Kidder Peabody and Co.; Helen F. Ladd, Associate Professor at the John F. Kennedy School at Harvard University;and Marshall Kaplan, Dean of the School of Public Affairs, University of Colorado, Denver. Remy Prud'homme, Visiting Professor in the Department,also lectured on the European experience with capital budgets.

The Department also sponsored several series of lectures during the year. Professor Manuel Castells, Professor of City and Regional Planning at the University of California,Berkeley,visited the Department during February 1983. Widely known for his writing on political economy, Professor Castells' lectures covered such topics as housing policy from an international perspective, urban reform at the local level, social values and the built environment, and neighborhood networks in the urban context.

Gene Slater, recent Department alumnus and recipient of a Loeb Fellowship at the Harvard Graduate School of Design during 1983, conducted a four-part workshop series on Public Financing for Housing and Community Development. Mr. Slater specializes in implementing downtown housing and mixed-use development projects and his presentations covered such topics as financing techniques for public/private partnerships, project structuring in the 1980s, and tax-exempt revenue financing for rehabilitation, single-family, multifamily, and commercial projects.

Pierre Laconte, the Director of the Land Use Study Group at the University of Louvain, Belgium, and a visiting lecturer in the Department, presented a two-week seminar jointly with Larry Susskind during March of this year. The subject was public/private partnerships for urban development in the US and Europe.

COMPUTER LABORATORY

The year marked the Department's modest leap into computer and microcomputers usage. Several machines, two printers,and two existing terminals were consolidated in a small space and instruction was offered on their usage. Almost as soon as it was discovered, the facility was solidly booked by students, faculty, and staff. This experience spurred us to prepare plans for a school-wide computer laboratory which we hope to implement with IBM equipment donations next year.

SPACE

Although the Department was not selected for the vacant space in Building 11, it was provided with the funds to create new offices in Building 3, thereby alleviating some of its chronic space problems. Reconstruction of this space started near the end of the fall term and was completed during the spring. We remain critically short of work space for students, and public spaces remain to be improved, but we are appreciative of the small steps forward during 1983.

ADMISSIONS

The Department received a total of 232 applications from prospective students -- 176 for the Master of City Planning program and 56 for the Ph.D. program. A total of 55 applicants were offered admission to the MCP program; forty-three of these individuals will be entering the program in September, two will be joint architecture/planning candidates,and one will be a joint law/planning student at Northeastern University's law school. About 14% of the incoming MCP class are from abroad, and 26% are minority.

Twenty-one applicants were offered admission to the Ph.D. program and sixteen students will be entering this program in September. Five percent of the incoming Ph.D. class are from abroad.

PLACEMENT

Course XI students continued to work in public-sector positions as they have in past years. Students from this year's graduating class have agreed to work in state and federal agencies such as the Executive Office of Administration and Finance, the Executive Office of Committees and Development, the Federal Emergency Management Agency, the Department of Justice, the Social Security Administration, the IRS, the Congressional Budget Office, and the U S Patent and Trademark Offices. Our students will also work in such local agencies as the Cambridge Housing Authority, the Boston Redevelopment Authority,and the Boston Neighborhood Development Agency.

Many employers are also looking for planners with computer skills necessary to implement new management systems. Examples include the Massachusetts Department of Public Health Division of Family Health Services and the Boston Housing Authority.

However, a trend has evolved in recent years in which our graduates have equipped themselves for the wider variety of situations than in years past. 1983 was no exception. Many Course XI graduates are now looking in the private sector at real estate development firms, financial institutions (often in municipal finance divisions), the real estate departments of banks and insurance companies, as well as large corporations such as Wang Laboratories and IBM (also in planning and real estate divisions). Many

graduates of the department continue to express their interest in public/private approaches to community economic development and seek opportunities to work with these organizations through financial institutions and development firms.

LOOKING AHEAD

If it is to remain at the top of its field, the Department will need to continue its evolution next year. Preparing for new programs in real estate development and urban operations management and for the new developing areas option in the MCP program will preoccupy many. The study group reassessing the Ph.D. program will involve others. Yet time and energy will need to be found to face other critical issues, including:

- Mounting a development program aimed at enlarging scholarship aid for regular students and Community Fellows.

- Rebuilding the volume of research conducted by Department members.

- Developing a program for computer literacy and introducing computer usage in a broad range of departmental subjects.

- Rationalizing our specialized offerings.

- Charting a new course for our undergraduate offerings.

The Department's future will depend, in no small measure, on how well we do in these areas.

GARY A. HACK

Laboratory of Architecture and Planning

The activity of the Laboratory of Architecture and Planning continued to grow in range and volume during the year 1982-83. All research and special programs conducted through the LAP serve its three broad objectives of 1) furthering state-of-the-art practice and teaching in the fields of architecture and planning, 2) linking the School with the activities of practitioners, and 3) encouraging research about emerging issues of concern to society and the professions.

While the LAP continued to support the initiatives of individual faculty members, it concentrated on promoting initiatives to bring together faculty to pursue research topics within the School's agenda.

1982-83 was the first year of operation for the Joint Program for Energy Efficient Buildings and Systems, a collaborative venture of the School of Architecture and Planning, the School of Engineering, and the MIT Energy Laboratory. Leon Glicksman, senior research scientist of the Department of Mechanical Engineering, is the Program Director, and LAP Director Michael L. Joroff is the Associate Director. Eight faculty members and thirty students were engaged in research projects. Joint Program staff also produced a weekly research seminar for faculty, students, and Boston-area practitioners; a publications program; and an ILP symposium for over 100 participants from building products manufacturers and architectural and engineering firms. Their current objective is to organize an industrial support program.

The School also launched two other School-wide programs to be based in the LAP. The East Asian Architecture and Planning Program, through publication, conferences, and other activities, will investigate the ways in which architectural and planning practices are affected by cultural, political, and economic transformations. Established with the aid of a grant from an anonymous donor, the Program awarded two travel grants to students who will explore topics related to its first conference, scheduled for August 1984. The School also initiated a program for short-term continuing professional education courses about design and planning issues in developing areas of the world. The first two-week seminar-cum-workshop, offered in August 1982, attracted participants from 16 countries. Senior staff from the US Agency for International Development and the World Bank participated as faculty. Plans are now being laid for an extensive array of short-term courses to be offered in the US and abroad in future years by architecture and planning faculty.

RESEARCH

The Community Energy Impact Study completed its investigation of the ways in which energy demands are affected by the changing structure of the US economy and the responses of households and businesses to that structure. Dr. David L. Birch is the principal investigator of the work, funded by the Department of Energy (DOE).

Growing Segments of the US Economy includes a number of projects for identifying rapidly growing segments in the US economy and of their job creation potential in a number of geographic areas of the US. Senior Research Scientist David Birch is the principal investigator for general projects funded by local governments and private industry. One such ongoing project is Developing a Small Business Monitoring System, designed to continuously improve a longitudinal version of the Duns Market Identifier (DMI) to analyze the US economy. The goal is to produce a full, easily incremented DMI file that could yield a continuously rolling data set, to be routinely updated.

Relating Transportation to Neighborhood Change is a project for assessing the effects of changes in transportation technology and energy costs on neighborhoods. Dr. Birch was the principal investigator, and the work was funded by the Department of Transportation.

Physical Scale Models to Describe Energy Phenomena is a project for investigating thermal, ventilated, and luminous environments. Principles of scale testing are being developed. Professor Harvey Bryan is the principal investigator. The Grunsfeld Foundation, MIT Cabot Solar Fund, the Metropolitan Museum of Art, and the Masonry Institute of America are funding the work.

The staff of the Downtown Shopping Malls project will prepare case studies of the planning and building process of mixed mall development in downtown locations. Cooperative activities of public agencies and private developers will receive special attention. Professor Bernard Frieden is the principal investigator for this work funded by the Hahn Foundation.

The Planning Urban Infrastructure for Secondary Cities in Egypt project continues to explore the problems faced by Egypt's rapidly growing secondary cities in the area of urban infrastructure planning and the

integration of such planning into the overall environmental design objective of those cities. The MIT Technology Adaptation Program has sponsored the project, for which Professor Ralph Gakenheimer serves as principal investigator.

Housing Policy in Sri Lanka is an analysis of housing options from that country, with particular emphasis on opportunities for government investment in infrastructure. Professors Nabeel Hamdi and Reinhardt Goethert are co-principal investigators. The work is funded by the National Housing Authority of Sri Lanka.

MIT Solar House V and the new Crystal Pavilion addition, constructed on the MIT campus, continue to demonstrate direct-gain solar space heat through the use of new architectural finishing materials. Principal Research Associate Timothy E. Johnson is the principal investigator. Current work is funded by the DOE and private industry.

Members of the Wavelength Switchable Windows Project will use computer models to develop methods for evaluating wavelength switchable windows through thermal and daylighting testing. Principal Research Scientist Timothy Johnson is the principal investigator for the project funded by the Polaroid Corporation.

The Architectural Case Studies program continues to prepare prototype cases. Accessible design, energy conscious design, and managing the architectural design process are the topics of studies already completed. Staff members are now preparing a case book about case method teaching in architecture. LAP Director Michael L. Joroff is the principal investigator of the project, supported by the National Endowment for the Arts.

The Ocean Risk and Modelling Techniques project is being directed by Professor Merrie Klapp, principal investigator. The work is funded by the Westinghouse Electric Corporation, Bell and Howell, and Atomic Power Laboratory.

Adaptive Referencing for Plato Catalog combined facilities for the automatic indexing of natural language text with the Adaptive Reference System (ARS). The project investigates whether automatic techniques are suitable for loading the thesaurus from which the ARS operates. Principle Research Scientist John Klensin is the principal investigator for the project funded by the Continuous Learning Corporation.

The Consistent System project continues to develop a large collection of application software for data management and data analysis. Principal Research Scientist John Klensin is the principal investigator, and the work is supported by private industry.

New Orleans in Transition is a two-year film project to record the planning and development for the forthcoming World's Fair in New Orleans. Professor Richard Leacock is the principal investigator and Glorianna Davenport is the project's director. The work is funded by the National Endowment for the Arts with support from USAir and the Sheraton New Orleans.

A thirty-minute film, Dakar: Reading the Contemporary African City, was produced for the Aga Khan Foundation. The film depicts the dilemmas of maintaining culturally conscious design in a rapidly developing city. Professor Richard Leacock and Thomas Piper were co-principal investigators for the project.

The LAP serves as the overall administrative home for the Aga Khan Program in Islamic Architecture, which includes professorships and fellowships located in the Department of Architecture and a documentation project centered in Rotch Library. Summer institutes abroad, a faculty exchange program, publications, student travel grants, and other activities strengthen the program and link it with its counterpart program at Harvard, with other programs here at MIT, and with other institutions and individuals throughout the world. Professor William L. Porter is the Program's director.

The Design as Inquiry project explores and tests the ways in which the process of design can act as a rigorous form of inquiry. A team of planners, architects, and engineers is investigating the distinctions between research of use to design and the use of design as a method of inquiry. Professor Donald Schön is the principal investigator, and the work is funded by the National Endowment for the Arts.

The ongoing Environmental Impact Assessment project continues investigation of the ways in which public agencies can better project and assess environmental impacts of proposed policies, programs, and public investments. Professor Lawrence Susskind is the principal investigator.

The Environmental Mediation Project will continue to develop and analyze techniques for mediating environmental disputes. Case studies of negotiation are being developed for use in training workshops and professional education. Professor Susskind is the principal investigator, and the work is funded by the Hewlett Foundation.

The Impact: 2 1/2 program is carried out by an inter-university consortium directed by Professor Susskind. The program monitors the long-term impact of the statewide program of tax and spending reduction

authorized by Referendum Proposition 2 1/2 passed in November 1980. The LAP serves as the center of operations for nine participating research organizations. The project is primarily funded by the Hyams and Permanent Charity Foundations and the Lincoln Institute for Land Use Policy.

The Sub-seabed Disposal of High-Level Radioactive Waste project analyzes the institutional obstacles to sub-seabed disposal of high-level radioactive waste. Alternative management systems are being designed for the long-term operation of a disposal program. Professor Susskind is the principal director of the project which is funded by the SANDIA National Laboratory.

SPECIAL PROGRAMS

The LAP presents a range of special programs to serve alumni and practitioners and to promote the School's research agenda. Among the continuing education courses taught by faculty and local professionals during the summer of 1982 were: Realities of Historic Preservation (R. Neilly); Passive Solar Energy--Tools for Design Application (H. Bryan); Daylighting (H. Bryan); Improving Professional Effectiveness (W. Ronco); Professional Practice Program in Settlement and Design--seminar and workshop (R. Goethert and N. Hamdi); and Design in Islamic Countries (W. Porter). These courses attracted more than 200 professionals from 35 countries. Plans were made this year for continuing education programs to be held during 1983-84 in Tunisia, Singapore, and Sri Lanka.

In July 1982, for the fourth year, the LAP hosted the Energy Design Institute of the Association of Collegiate Schools of Architecture. This intensive week-long course attracted architectural faculty from schools throughout the country. Professors from the Schools of Architecture and Engineering played a leading role as faculty of the Institute. Representatives from almost all of the nation's architectural schools have now attended this MIT-based Institute.

The Joint Program for Energy Efficient Buildings and Systems presented a one-day ILP symposium attended by over 100 professionals. MIT staff familiarized them with the extensive range of MIT research related to the Program. Another two-day conference on revitalizing Boston's public housing drew several hundred of the Boston area's design and public housing officials. Fifty city officials also participated in a five-day workshop about managing community development presented by the Community Development Directors Association and hosted by the LAP. In association with the Adaptive Environment Center, the LAP organized a two-day workshop about techniques for teaching accessible design in schools of social services, education, and architecture.

DISSEMINATION OF RESEARCH FINDINGS

The LAP's commitment to disseminate the findings of research to as large a professional and public audience as possible was particularly well carried out this year. The Impact: 2 1/2 Project, directed by Professor Lawrence Susskind, proved a model for effective dissemination. LAP Research Affiliate Thomas Piper won a regional Emmy award for the best public interest television program for an hour-long documentary based on the Impact: 2 1/2 Project. Project staff used a wide range of media to communicate their findings to the public. An "Op-Ed" page column by Professor Susskind appeared in the Boston Globe. Professor Susskind and 12 members of the research staff testified at a daylong symposium on Proposition 2 1/2 at the State House, attended by 150 state and local officials and 40 persons from the media. The event received prime-time coverage on commercial and public television. At the symposium an 80-page status report was made available to the press. Project Director Susskind appeared in debates about the Proposition on cable television broadcasts repeated in a number of Massachusetts towns. Finally, Proposition 2 1/2: Its Impact on Massachusetts, a 500-page report covering the first full year of research findings, was published by a commercial press. The LAP continued to house the Impact: 2 1/2 Newsletter which reports monthly to Massachusetts officials and citizens about the impact of the law on the Commonwealth's cities and towns.

The LAP Publications Program now offers 30 titles, including those produced by the MIT Joint Program for Energy Efficient Buildings and Systems, the Aga Khan Program, and the Program for Public Negotiation. The Environmental Impact Assessment Review, published by Plenum Press and edited by LAP staff member Teresa Hill under the direction of Professor Susskind, completed its third year of publication. The MIT Press took over publication of the new environmental design journal, Places. Edited by Professor William Porter, with associates from MIT and the University of California at Berkeley, the journal originated as a LAP-based project funded by the National Endowment for the Arts. The international journal of housing, Open House, was published last year as a joint venture of the SAP group in Holland and the LAP; Professor Nabeel Hamdi was the LAP-based editor.

STAFF

Several new research staff were appointed to the LAP this year. Cynthia Ware joined the LAP staff as Communications Coordinator for the School and Director of Publications for the LAP. Teresa Hill became the

new editor of the EIA Review; Susan Jones became the Assistant to the Director for the Aga Khan Program; Jane Serio assumed the position of Project Administrator of the Impact: 2 1/2 Project. Patricia Claffey and Margaret Keeler joined the LAP's support staff.

Continuing on the LAP's core staff were: Donna M. T. Herlehy, LAP Assistant Director; Senior Research Scientist David L. Birch; Principal Research Scientists John Klensin and Mona Serageldin; Research Associates Rebecca Packard and William Parsons; administrative staff Margaret B. Ševčenko, Administrative Assistant H. Sharon Trohon, and support staff Catherine Gwinn Shick. Bernard Spring, Thomas Piper, Donna McDaniel, Hasan Khan, and Samir Abdulac continued as research affiliates of the LAP. Gordon King, interested in issues of community development, and Jennifer Leaning, MD, interested in issues of energy disaster planning, joined the ranks of the LAP's research affiliates.

In addition to LAP-based research work, several of the LAP staff were busy with professional activities. LAP Director Joroff was elected to a third term as Chairman of the board and President of the Architectural Research Centers Consortium; in this capacity he serves as a member of the Research Council of the American Institute of Architects. He continued to serve on the boards of the Association of Collegiate Schools of Architecture's Journal of Architectural Education, the Boston Architectural Center's Energy Design Institute, and the Adaptive Environments Center. LAP Assistant Director Donna Herlehy was elected Chair of the Brookline Arts Council. Dr. John Klensin continued to chair the American National Standard Institute's technical committee for PL/I standardization. Dr. Birch's research on job generation by small business was described in more than a dozen of the nation's business journals, and he presented the findings of his work at more than a dozen conferences in the US and abroad. Dr. Jennifer Leaning is serving as Staff Director for the Physicans for Social Responsibility. With colleagues in the Department of Urban Studies, she is writing a book about nuclear war disaster management.

COLLABORATIVE ARRANGEMENTS

The LAP continues to extend its involvement in projects through collaboration with a variety of organizations. LAP projects are currently linked in formal collaborative arrangements with researchers at more than two dozen universities. The LAP is a leader of the Architectural Research Centers Consortium (ARCC) which represents and promotes collaboration among 32 major university-based research centers. The LAP leads a dozen Massachusetts university participants in the Impact: 2 1/2 project described above. LAP project staff originally created, planned, and operated the Boston Neighborhood Network, a nonprofit community service-cum-research organization. The LAP is one of four universities playing a major role in this group. The LAP's Continuing Education Program is offered in collaboration with the Office of Special Programs of the Harvard Graduate School of Design. The LAP-based work on environmental policy negotiation is part of a multiuniversity program on negotiation, based at the Harvard Law School. Professor Susskind is director of the Environmental Negotiation Program, a part of the Harvard Negotiations Project.

The LAP and the Association of Collegiate Schools of Architecture (ACSA) collaborate on an annual summer institute on teaching technology in schools of architecture. The LAP is an active participant in MIT's efforts to foster collaborative research and education programs with the University of Tokyo. Collaborative teaching programs with schools of architecture in China are also being explored.

DEVELOPMENT PLANS AND ISSUES

The LAP will increase its efforts to coordinate development strategies within the School and will primarily provide support to projects which fit its development agenda. The LAP will continue to seek advice and assistance from practitioners in the field, alumni, members of the School's Visiting Committee, and representatives of client organizations.

The LAP is further extending its networks for collaboration on all of its activities. This strategy is essential for coping with the restrictive economic situation in research funding. We continue to enhance the proportion of support that we receive from industry and foundations. The problems imposed both by Federal funding cutbacks and by more stringent governmental regulations continue to be difficult for us. We shall continue to work with the MIT administration to deal with these issues as they arise.

MICHAEL L. JOROFF

School of Engineering

The past academic year was a time of intensive self-examination, development of long-range goals and plans, setting of priorities for future development of the educational and research programs of the School and its academic departments and interdisciplinary centers and laboratories, and the launching of several major initiatives within the School and in cooperation with the other MIT Schools.

A long-range planning effort, started in the spring of 1982, culminated in the formulation of goals, critical evaluations of existing programs, and the establishment and prioritization of future initiatives for each unit of the School. Particular attention was paid to the identification of new activities likely to have a major impact on engineering education and research, and on the nation as a whole. Similarly, existing activities were examined critically to identify those which might be reduced, modified or eliminated in order to make resources more available for new initiatives. The plans of all the departments, centers and laboratories were reviewed collectively by the Engineering Council and the Provost at a three-day retreat in October, after which modifications were made in the plans and priorities of these units of the School and major School-wide initiatives and priorities were identified. These plans constitute working guides for allocation of Institute resources to the units of the School and for establishing fund-raising priorities.

Discussion of the goals, new initiatives and priorities for the departments, centers and laboratories which emerged from the long-range planning study appears in their inidividual reports. Particularly notable initiatives include: The Next Age of Space; Biochemical Engineering; Rebuilding America's Infrastructure; Very Large Scale Integrated Circuits Program; Electronic Materials Processing; Manufacturing Research and Education; Engineering Design Education; and Innovation in Nuclear Power Reactor Design.

On a School-wide basis, a number of issues surfaced which were common to several academic departments, but two in particular were common to all departments and of the highest importance and priority for the School as a whole. First was the need for time and resources for the development of new curricula and subjects of instruction, particularly at the undergraduate level, and for their documentation in textbooks, software or other appropriate media. This is an area which has been neglected in recent years owing to budget stringencies and the heavy undergraduate teaching loads the School has faced. Second is the area of computer integration into the educational experience at all levels, but most especially in the undergraduate programs of the School.

The identification of computers in education as one of the most important issues for the School led, during the year, to the development of the major initiative known as Project Athena which now involves all five schools of the Institute. Athena is conceived as an experiment based on the premise that microcomputers with advanced computational and interactive graphics capabilities represent a revolutionary new medium for enhancing learning. A key goal of Athena is to tap this new computational and graphics power to develop innovative ways to help students grasp abstract concepts under the guidance of their teachers, give new life to laboratory experiments, enhance the learning of design, and foster the rapid development of intuition. From a technical point of view, a key goal will be to establish "coherence" among various supplier's hardware such that all machines, linked together in a network, will function with a common protocol and operating system in a way that students and faculty can exchange software easily and move from one manufacturer's equipment to another. From an educational point of view the goal is to develop new curricula, laboratories and disciplinary and design subjects which take full advantage of computational and graphical tools.

Undergraduate enrollment in the School increased again this year from 2,378 in 1981-82 to 2,428, while graduate enrollment declined by about 10% from 2,156 to 1,919. Seventy percent of the undergraduate majors are now registered in the School. The School is particularly concerned about the growing demand by undergraduates to major in Electrical Engineering and Computer Science (which now has 31.5% of undergraduate majors), and especially in Computer Science. If this trend continues, either significant expansion of the faculty will be necessary or steps must be taken to control registration in this area of the School. In an effort to address the continuing decline in the number of Ph.D.'s entering careers in engineering education, a Forgivable Loan Program was instituted in the School with funds given by the General Electric Foundation and the Ford Foundation.

The Second Summer Program for MIT minority students provides, during the summer following the freshman year, both an academic component that strengthens the student's skills in mathematics, computer methods, engineering thermodynamics and mechanics, and hands-on practical experience in cooperating companies.

Under the direction of Professor Wesley L. Harris, who established the program in 1979, this activity has been highly successful in contributing to the career development and guidance, professional encouragement and retention of minority undergraduates at MIT. A total of 19 freshmen were selected to participate during the summer of 1983 and were placed at DuPont, Goodyear, Hewlett-Packard, Monsanto and Honeywell. Professor James B. Hubbard, Jr. joined Professor Harris this year as co-director.

The School continued to provide space and financial support for the student chapter of the National Society of Black Engineers. The departments and the Dean provided support for the Minorities in Engineering Program (MITE). Directed by Professor Ernest G. Cravalho, this effort brings a small select group of minority high school students to MIT in the summer following their junior year for an introduction to the profession of engineering and an intensive academic experience including mathematics, mechanics, computers, technical writing and design. This program was operated on an Institute-wide basis as UNITE under support of the U.S. Air Force from 1978 to 1982. With the expiration of this funding, the program has been re-oriented to engineering which was its focus from 1975 to 1978.

ENGINEERING INTERNSHIP PROGRAM

For the summer of 1983, 41 sophomores were placed in the Engineering Internship Program (EIP), compared with 38 in the previous year. The total enrollment in the program is now 104, with 36 companies participating. Beginning in the sophomore year, the EIP provides work experience in the cooperating companies during two summers and one academic term and leads to the simultaneous award of S.B. and S.M. degrees with thesis done in collaboration with the company.

A number of companies participating in the program have been under financial pressure due to the downturn in certain sectors of the U.S. economy and were not able to take new students this year; however, all participating companies have continued support of the students already in the program. In anticipation of this situation, the Director, Mr. John Martucelli, undertook aggressive efforts to recruit additional companies in the fall of 1982. By spring of 1983 nine new companies had joined the program, indicating the presence of strong industrial interest in the EIP and suggesting the potential for significant growth when economic times are better. For the coming year the goal is to add several more companies, keeping in mind the need to balance the company needs with the distribution of students by discipline in the School, and the need to insure the quality and integrity of the educational experience.

MANAGEMENT OF TECHNOLOGY PROGRAM

This Program, which leads to the S.M. in Management of Technology jointly awarded by the Sloan School of Management and the School of Engineering, is described in Dean Siegel's report. The Program completed its third development year with the graduation of 13 students in 1983, all of whom have secured excellent jobs, primarily in industry. A steady-state size of 40 to 50 students is planned when the Program is fully developed.

TECHNOLOGY AND POLICY PROGRAM

This Program educates men and women for leadership in the issues confronting society where technical and nontechnical issues both dominate. This is accomplished through a rigorous interdepartmental curriculum leading to the S.M. in Technology and Policy awarded by the School. The curriculum combines a strong base in advanced technical subjects with subjects in economics, political science and law. Applications for this innovative program are increasing; many of the students joining the program have substantial professional experience, both in the U.S. and abroad. Placements continue to be excellent, with about two-thirds of the graduates working in industry and consulting, and the remainder going to government or to further studies.

Professor Richard L. de Neufville, Chairman of the Program, answers many requests from government for information on the program, reflecting their interest in this type of education and in its graduates. The first students were admitted in the fall of 1976, and this year the program awarded its one hundredth S.M. degree.

SCHOOL-WIDE ELECTIVES PROGRAM

Following a several-year experiment under the supervision of an ad hoc committee chaired by Professor Emmett A. Witmer, a permanent program of engineering school-wide elective subjects was established by vote of the engineering department heads and approved for listing in the MIT catalog by the Committee on Educational Policy.

These subjects meet one or more of the following criteria: integrate knowledge from several disciplines, couple engineering with disciplines found outside the engineering school, function as service subjects for engineering and non-engineering students, and/or are germane to several engineering fields. The

present subjects include such topics as physical system computer modeling, technology and law, management in engineering, entrepreneurship, and system analysis.

SCHOOL APPOINTMENTS

During the past year Professor David N. Wormley assumed the position of Head of the Department of Mechanical Engineering. He replaced Professor Herbert H. Richardson who became Associate Dean of the School of Engineering last Fall.

Professor H. Kent Bowen, Ford Professor of Engineering, replaced Professor Merton C. Flemings, Jr., Toyota Professor of Materials Processing, as Director of the Materials Processing Center. Professor Flemings is currently serving as Head of the Department of Materials Science and Engineering, replacing Professor Walter Owen who returned to full-time faculty responsibilities.

Professor Fernando J. Corbato has been named Acting Associate Head for Computer Science and Engineering effective July 1, 1983. He will replace Professor Peter Elias, Edwin S. Webster Professor of Electrical Engineering, who will return to full-time faculty duties. Professor Corbato returns to the position of Associate Head after serving as Director of Computing and Telecommunication Resources for MIT since 1980.

Professor Jack L. Kerrebrock, Richard Cockburn MacLaurin Professor of Aeronautics and Astronautics, returns to the position of Head of the Department of Aeronautics and Astronautics July 1, 1983 after a two-year leave of absence during which he served as Associate Administrator of NASA's Office of Aerospace Technology. Professor James W. Mar, Jerome Clark Hunsaker Professor of Aerospace Education, who served as Head of the Department during Professor Kerrebrock's absence, will return to full-time faculty responsibilities.

Associate Professor Nicholas A. Ashford, a School of Engineering faculty member, assumed the position of Director of the Center for Policy Alternatives. He succeeded Professor J. Herbert Hollomon, Japan Steel Industry Professor of Engineering, who returned to full-time faculty responsibilities.

Associate Professor James M. Utterback, also a School faculty member, was appointed as Director of the MIT Industrial Liaison Program effective July 1, 1983.

Donna R. Savicki replaced Mr. Frederick J. Quivey as Assistant Dean of Engineering for Administration. Mr. Quivey left MIT to assume a position in industry.

Eric C. Johnson was named the first Assistant Dean of Engineering for Resource Development. Mr. Johnson returned to MIT from a two-year leave of absence from his position as Executive Officer of the Sustaining Fellows Program.

GERALD L. WILSON

Department of Aeronautics and Astronautics

The Department's emphasis on undergraduate education is continuing to attract more than its share of the undergraduates; there was a 13 percent increase in the number of undergraduates enrolled and the total represents more than eight percent of the student body. Research volume has increased more than the inflation rate to almost $8 million. The Department faculty, on the whole, have responded to changing national goals and have attracted funding for new programs.

During the past year, the mezzanine floor in the high bay area of Building 33 was completed. This will greatly enhance the manner in which our required Experimental Projects Laboratory subject is taught. The steep amphitheatre classroom, Room 35-225, in which Unified Engineering (our most important undergraduate subject) is taught, is so ill-equipped and ill-shaped that the teaching process suffers. The remainder of the third floor in Building 37 was finally vacated by the previous tenants, but requires major renovations before it is of the same quality as the space we relinquished in Building W-91.

Under the leadership of Dean Wilson, the Department constructed a Long Range Plan. Two new challenges were identified for Aeronautics: (1) Advanced Air Traffic Control Systems (AATCS) and, (2) The Wright Brothers Wind Tunnel Facility (WBWTF). The nation and, indeed, the world is upgrading air traffic control systems, and the Department believes it can contribute ideas to the form and structure of AATCS. The Wright Brothers Wind Tunnel is of a double-shell construction and was designed originally to be operated at 4 atmospheres of pressure. This makes it possible to attain Reynolds Numbers of about 20 million per foot if the working fluid is freon at a pressure of 4 atmospheres. Such a capability would be a national asset and of great value in research and development where high Reynolds Numbers are critical. The Department can afford such a facility only with a consortium formed of aerospace companies and government agencies.

The Long Range Plan also identified a major new challenge in Astronautics entitled "Control Configured Spacecraft Technology" (CCST). Research which will be carried out under this rubric will span all the divisions of the Department and will include such topics as space structures, propulsion, space power, fault tolerant systems, teleoperators and system optimization. Two other major new challenges also identified in the Long Range Plan are "Computer Enhanced Engineering Technology" (CEET) and "Instrumentation". CEET is the result of the recognition of the pervasive nature of computers and software in all aspects of aeronautics and astronautics -- from computer-based mathematical models to micro-computers in a teleoperator -- to the software in flight control systems. Instrumentation represents a re-entry of this Department into the broad field of instrumentation which is defined as the art and technology of measurement. For example, almost all research in the Department can identify a need for new sensors.

The Long Range Plan identified the need for three new junior faculty appointments for the major new challenges of CCST, CEET, and Instrumentation.

The Department was able to measurably improve its posture to perform research at the forefront of aeronautics/astronautics by means of the following actions: (1) Gifts from CADAM INC of computer-aided design software, and from the Perkin-Elmer Corporation of the computer hardware for four work stations will give the Department the capability to enhance its research activities with computer-aided design. (2) An Aerospace Simulation Facility, made possible by the acquisition of two DEC VAX computers, has been created by Professors Murman and Elias to fully exploit the opportunities in Air Traffic Control Systems and Computational Fluid Dynamics. (3) To take full advantage of these and other computer-dependent opportunities, the Department has added a software engineer to its roster. (4) The data handling and other operational capabilities of the Wright Brothers Wind Tunnel under Professor Baron's leadership have been further upgraded by yet another gift from the Fairchild Republic Company. (5) Professor Crawley is the recipient of an instrumentation grant from the Department of Defense totaling almost .25 million dollars for the construction of a facility for the simulation of conditions in low earth orbits for structural testing.

UNDERGRADUATE PROGRAM

Undergraduate enrollment trends are indicated in the following table:

	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
Sophomores	39	53	70	78	91	86
Juniors	45	37	47	70	73	86
Seniors	29	45	41	55	62	85
Totals	113	135	158	203	226	257

Fifteen seniors chose the Avionics Option for their undergraduate program; 15 juniors have elected the same option.

The incoming '83-'84 sophomore class will probably be the largest in the history of the Department. Of special note: 25 are women, which is about twice the number in the previous class.

The Department has just completed its first year with the requirement that undergraduates perform at a grade level of C or better in nine required subjects. During the Fall term nine sophomores, seven juniors and one senior were required either to do remedial study or repeat the subjects wherein the C standards were not met. The numbers for the Spring term were seven sophomores and four juniors. Undergraduate performance is being more carefully scrutinized by Professor Witmer and the Undergraduate Committee because of this increase in the minimum academic requirements. The students appear to be appreciative of this added attention and the ensuing advice.

The project undertaken by the students in 16.85 Space Systems Engineering was the design of a space station. This was a very timely project because eight companies were also engaged at the same time on studies of space stations for NASA. The class was divided into four teams with each team responsible for a different aspect of the space station. The faculty involved were Professors Miller, Crawley, Martinez-Sanchez, and Akin, who each directed the efforts of one team. Each group of students elected a team leader and an overall project leader. The results of the MIT study were briefed to NASA personnel and, as a result, two of the student leaders were invited to attend the presentations of the industry studies at NASA Headquarters in Washington, D.C. A final report was prepared by the class and edited by the team leaders during IAP. A final copy was printed and has received wide distribution among interested NASA and industry personnel.

Our Department program entitled Computer Enhanced Engineering Education(CEEE) was temporarily held in abeyance while the School of Engineering deliberated on its Computers in Education project which is now called Project Athena. At the beginning of the Fall semester, the Department offered limited computer hardware resources to a small number of faculty with the understanding that some thinking about CEEE would occur. By pooling resources from a number of diverse sources, the Department had hoped to create a modest network of computers in Building 33. However, the Department intends to re-think its ideas in light of the Project Athena.

During the past year, Professor Louis offered a new undergraduate elective subject, 16.52 Energy Conversion. It is hoped that this subject will have appeal for all undergraduates since the focus is not energy conversion for aerospace applications. A new subject, 16.10 Aircraft Performance, Stability and Control suitable for seniors as an elective, has been prepared by Professors Miller, Simpson, and Elias and will be offered for the first time in the Fall semester of 1983. In the summer of 1982, a group of faculty led by Professor Haritonidis reviewed the modes of operations used in the teaching of the Experimental Projects Laboratory, a key subject in the Department's required curriculum. As a result of those deliberations, the Experimental Projects Laboratory enjoyed its most successful year of recent times.

GRADUATE PROGRAM

The number of graduate students in the Department appears to have stabilized at a new plateau of about 185. During the past year, 109 graduate students were research assistants, two were teaching assistants and 27 were recipients of fellowships. For the Fall of 1983, 224 applications were received, which is an increase of five percent over the previous year. Admission was offered to 127 and financial aid to 46; 70 are expected to enroll which will comprise a total graduate enrollment of 186. This graduate population will include 13 women, eight minority students (a 100 percent increase), and 45 international students (a 16 percent decrease). The international students in the graduate population will now be less than 25 percent, and will come from 24 different nations. The largest contingents are from Greece (5), France (4), Canada (4) and Hong Kong (4).

The Doctoral Committee, chaired by Professor Martinez-Sanchez, admitted 26 to the Doctoral Program (five persons who took the qualifyng exam did not pass). This brings the number of doctoral candidates in the Department to 63.

The largest group of graduate students are those interested in Instrumentation, Guidance and Control. This is primarily because the Draper Laboratory is the single largest support of graduate students (about 28 students received full financial support from the Draper Laboratory). This has created thesis supervision problems for the Instrumentation, Guidance and Control Division of the Department. To improve the education of the students and to strengthen the ties with the Draper Laboratory, the Department created the position of Director of Draper Fellows. Professo r Markey has agreed to assume responsibilities for that position.

Two new subjects are being added: 16.10 Aircraft Performance, Stability and Control, by Professors Miller, Simpson, and Elias; and 16.71J Computer Applications in Transportation by Professor Odoni.

RESEARCH

Research funding conducted by faculty reached a total of almost $8 million for the fiscal year 1983. This volume is expected to continue to grow because the small number of faculty who have not been successful in recent years to attract research funding have been able to adapt to the changing nature of support. There are two laboratory entities within the Department which merit the financial benefits given to the so-called Interdepartmental Laboratories. These are the Gas Turbine and Plasma Dynamics Laboratory headed byProfessor Covert, and the Space Systems

Laboratory/Technology Laboratory for Advanced Composites jointly headed by Professors Mar and Miller. Both of these groups have research volumes in excess of $2 million ($1.5 million is a necessary condition) and both involve a substantial number of faculty and students. The latter group, for example, has 12 faculty, almost 40 graduate students, and over 50 UROP students. It has been necessary during the past year to create a Research Staff Administrative position for this group so that the budget, payroll and purchasing could be properly managed. Ms. Ping Lee, who formerly was part of the Department's Headquarters staff, has assumed administrative responsibilities for this group. The Gas Turbine and Plasma Dynamics Laboratory also created a Research Staff Administrative position and promoted Ms. Holly Rathbun to that position.

The sale of the surplus equipment from Building W-91 which housed the supersonic wind tunnel yielded a disappointingly small amount of money. Consequently, some of the hoped-for improvements in the Wright Brothers Wind tunnel will not be possible at this time.

The past year of research is best characterized as one in which programs begun in the previous year were consolidated. A review of research in progress indicates a number of important results will be accomplished during the forthcoming year and will be reported in 1984. However, for the past year there are some items worthy of special mention: (1) Professor Akin has been given the go-ahead for a project dubbed "EASE", Experimental Assembly of Structures in EVA. This project will culminate in a flight experiment aboard the Space Shuttle during calendar year '84. (2) Professor VanderVelde is the leader of a multi-task research program in computer science from NASA Headquarters. Professors Widnall and Thompkins of this Department, Professor Arvind of EECS, Professor Madnick of the Sloan School, and Drs. Smith and Furtek of the Draper Laboratory are other participants. (3) The construction of the Blow Down Turbine Facility under the direction of Professor Epstein is essentially complete. Successful trial runs have been held at room temperature and the eddy current brake performance exceeds the requirements. (4) Byron Lichtenberg of the Man-Vehicle Laboratory was chosen to be the first U.S. Payload Specialist and is scheduled to fly with a Man-Vehicle Laboratory experiment on the first Space Lab mission slated to go into orbit in the Fall of 1983.

FACULTY AND STAFF

Two of our assistant professors were given special Chairs during the past year. David Akin, whose interests are in Space Systems Engineering, has been made the Rockwell International Assistant Professor, and Joseph Haritonidis, who is an experimentalist on the nature of turbulence, was appointed as the Esther and Harold E. Edgerton Assistant Professor of Aeronautics and Astronautics.

During the past year, the Department completed searches for two assistant professors, one in the field of Biomedical Engineering and the other in the field of Instrumentation. Their appointments, which are expected to be approved during the summer, will bring the number of assistant professors to ten. This represents over 25 percent of the Department's faculty roster, the largest ever in the history of the Department.

Ms. Donna Savicki, who has very ably served as the Department's Administrative Officer for five years, became the Assistant Dean of Engineering for Administration in the School of Engineering in September, 1982. Ms. Helen Raine, who has been with Headquarters since 1979, was promoted to the position of Administrative Officer for the Department. Both the School of Engineering and the Department are fortunate to have these capable women on their staffs. Ms. Carol Hughes, who has been working in the Medical Department since 1973, has taken the position of secretary to the Department Head.

Three faculty members retired during the past academic year. They were Associate Professor E. Eugene Larrabee, who joined the faculty in 1946; Professor H. Philip Whitaker, who joined the faculty in 1947; and Professor Morton Finston, who joined the faculty in 1951. The Department owes much to these three who have left their imprints in many different ways. Mrs. Barbara Marks, who has served as secretary for many different faculty and has been with the Department since 1954, has also retired. We will miss all of these wonderful people and wish them well as they commence their new activities.

Two Visiting Scholars, Guo-Cai Tang and Hongming Wang, returned to the Peoples Republic of China, while two others from that country, Zong-An Hu and Zong Shu Tian, joined our staff as Visiting Engineers.

HONORS

Professor Sheila Widnall was elected a Fellow of the American Association for the Advancement of Science and also a Fellow of the American Physical Society.

Professor Mar gave the 24th Structures, Structural Dynamics and Materials lecture of the Annual Conference sponsored by the American Institute of Aeronautics and Astronautics. The title of the lecture was "Fracture, Longevity and Damage Tolerance of Graphite Filamentary Materials".

Professor James McCune received the 1983 Department of Aeronautics and Astronautics Teaching Award, presented by the students of the Department.

Assistant Professor Bruce Walker received the Graduate Student Council Award for Teaching.

Professor Marten Landahl was elected a Fellow of the American Physical Society, 1982, and elected Member of the Royal Swedish Academy for Engineering Sciences, 1983.

Sir William R. Hawthorne received the Royal Medal from Queen Elizabeth for his contributions to the understanding of gas turbines. Sir William was also voted by the American Society of Mechanical Engineers for Honorary Membership, the highest honor bestowed by that Society. He gave the Calvin Rowe Lecture at the 1983 ASME Spring meeting in Phoenix.

Professor Theodore H.H. Pian was appointed Honorary Professor of the Beijing Institute of Technology, Beijing, Peoples Republic of China in 1982. Professor Pian was also appointed Honorary Professor of the South Western Jiaotong University, Emei, Peoples Republic of China in June of 1983.

Professor Trilling was elected a Fellow of the American Association for the Advancement of Science.

The winners of the Department's academic awards for undergraduates were as follows:

HENRY WEBB SALISBURY AWARD

This award, established in the memory of Henry Webb Salisbury ('33), is given annually to a graduating senior in Course 16 for the highest degree of academic achievement. This year's co-winners are:

Richard Abraham Shapiro	16C	'83
Robert Otto Voss	16B	'83
Farhad Zarinetchi	16	'83

JAMES MEANS MEMORIAL PRIZE

For excellence in Space Systems Engineering:

Sarah Ann Gavit	16	'83
Javier deLuis	16	'83

LUIS DE FLOREZ AWARD

Awarded to undergraduates who have demonstrated "original thinking or ingenuity" in Aeronautics and Astronautics. This year's winners are:

Albert Maurice Amzallag	16B	'83
David Edward Bauer	16	'83
John Kenneth Einhorn	16	'84
Alexander Gruzen	16	'84
Tariq Osman Hashim	16	'84
Mark Russell Krebs	16	'83
Dean Matthew Starovasnik	16	'84
James Ming Wang	16C	'84
Mark Wu	6	'85

JAMES W. MAR

Department of Chemical Engineering

The Department had a very successful year in the quality of new graduate students, the quality of new faculty, and new prestigious awards and recognitions of the faculty. The current recession in the job market for BS graduates is expected to lead to a decrease in student population and research programs. The Department currently has the highest student to faculty ratio at MIT.

THE UNDERGRADUATE PROGRAM

Undergraduate enrollment increased to 356 students, an all-time record, from the previous total of 342. A combination of lecture presentations and multiple recitation sections for core subjects accommodated the large classes and continued to provide effective student-faculty interaction. The following table shows the trends in undergraduate enrollment.

Undergraduate Enrollment

	1976-77	1978-79	1979-80	1980-81	1981-82	1982-83
Sophomores	107	98	107	99	127	133
Juniors	106	114	111	109	104	112
Seniors	99	106	117	111	111	111
Total*	312	318	335	319	342	356

*Does not include students in the 5-year program who transferred to graduate school.

Considerable progress was made in improving the undergraduate laboratory offerings. A new separations laboratory (10.94) was offered both terms. In addition, plans for a new undergraduate laboratory have progressed under the guidance of Professor T. Alan Hatton. This laboratory will first be offered in the Spring term 1984. Also, class size doubled in the Polymer Science Laboratory (10.67).

THE GRADUATE PROGRAM

Limitations in financial support required that the number of new students admitted in the fall and spring be reduced from that of previous years; a major factor was the large increase, from 85 to 115, in the number of doctoral students. Although the number of job offers to graduates was reduced markedly from previous years, nearly all master's and doctor's degree recipients were placed.

Graduate Enrollment

	1978-79	1979-80	1980-81	1981-82	1982-83
Total Graduate Students	202	228	207	230	208
Doctoral Students	74	73	77	85	115

Thirty-eight graduate students were enrolled in the Practice School last year with about 40 percent involved with our doctoral program, and the remaining 60 percent equally divided between the 5-year program for MIT undergraduates and normal SM Practice School program. Students participated in project work at our Albany, Oak Ridge, and Bethlehem stations; a new station was opened at Brookhaven National Laboratory which is operated by Associated Universities for the US Department of Energy (DOE). The Albany station completed its sixth year of operation under the sponsorship of the General Electric Company at its Silicone Products Plant in Waterford, NY and its Noryl Products Plant in Selkirk, NY. The Bethlehem station is now in its second year of operation at the steel plant and research laboratories of Bethlehem Steel Corporation's operation in Bethlehem, PA. Following last summer's session, the Oak Ridge station, located in Oak Ridge, TN and hosted by Union Carbide's Nuclear Division at Oak Ridge Laboratory, was closed after 32 years of operation.

Projects at the Albany station focus on process improvement, development, and design in a number of polymer production operations. Projects at the Bethlehem station are coupled to on-going process development and improvement work associated with steelmaking, coke formation, and by-product recovery. In addition, many projects deal with waste water treatment and air pollution as well as energy conservation. At Brookhaven, projects this summer dealt with synthetic fuel production via Fischer-Tropsch reactions, high temperature electrolysis, cyclic gas adsorption, and localized corrosion. Students usually attend two of the three stations during a single semester. The original program philosophy of an active internship has been maintained by exposing students to the practice of chemical engineering, utilizing group approaches to solving problems, and developing communication skills.

Station directors for last year include Visiting Assistant Professor William Doerr (MSCEP 1974, ScD 1979) who operated the Bethlehem station during the summer semester and Assistant Professor George Huff (ScD 1982) who directed the Oak Ridge station during the summer and currently directs the Bethlehem station, and Assistant Professor Montgomery Alger (BS and MSCEP 1978, PhD University of Illinois) who directs the Albany station. Professors Alan Hatton and Jefferson Tester will jointly direct the Brookhaven station during its first year of operation.

The "Friends of the Practice School" committee began the second phase of fund raising by selecting Robert Richardson (ScD 1954) as its chairman. The purpose of the second phase is to renew commitments from our 22 sponsoring companies in order to sustain our fellowship aid program to Practice School students while they are taking classes in Cambridge. This fellowship support is in addition to support provided by the host companies to students while they are in residence at the stations. As of June 1, 1983, the sponsoring companies of the program include Air Products, Atlantic Richfield, Badger, Bechtel, Bethlehem Steel, Bonner and Moore, Dow Chemical, E.I. DuPont de Nemours, Exxon, Gulf Oil, Halcon, Mobil Oil, PPG Industries, Republic Steel, Rohm and Haas, Shell Oil, Standard Oil of California, Standard Oil of Ohio, Stone and Webster, Sun Oil, Union Oil, and Wheelabrator- Frye. Financial aid provided by the host and sponsoring companies is a major component in ensuring the continuation of this unique educational program at MIT. The Department appreciates this expression of support and confidence in the Practice School Program.

NEW DEVELOPMENTS

Mark A. Kramer was added to the faculty as a new Assistant Professor. He just received his doctorate from Princeton University. His field is in mathematical modeling and parameter estimations, and he is a member of the Institute Task Force on System Dynamics and Control.

The Department has launched a program to develop a new undergraduate process laboratory under the leadership of Professor T. Alan Hatton. The students will become familiar with six to eight sets of experiments which will tie together what they have learned in classrooms, and be exposed to new technologies including supercritical fluids, biotechnology, and vapor deposition in integrated circuit processing.

Internationally distinguished visiting scientists and scholars to the Department include Professor John Anderson, Department Head elect at Carnegie-Mellon University and Professor Paul Rempp of Strausbourg, France.

Guest speakers for the Department's annual seminar series were: Professor John L. Anderson (Carnegie-Mellon University), Dr. Michael L. White (Rohm and Haas Research Division), Professor R. Byron Bird (University of Wisconsin), Professor Gerald G. Fuller (Stanford University), Dr. Michael Ross (Genentech Corporation), Professor Curtis Frank (Stanford University), Professor Walter H. Stockmayer (Dartmouth College), Dr. William J. Ward (General Electric Company), Professor Raymond G. Cox (McGill University), Professor Fredrick L. Dryer (Princeton University), Professor Barry Ninham (Australian National University), Professor Michael Paulaitis (University of Delaware), Professor L. Douglas Smoot (Brigham Young University), Professor George M. Homsy (Stanford University), Mr. George M. Keller (Standard Oil Company of California), Dr. Henry M. Princen (Exxon Research and Engineering Company), Professor Gregory Stephanopoulos (California Institute of Technology). Members of our Department who also spoke at the annual seminar series were: Professor Jefferson W. Tester, Professor Charles L. Cooney, Professor T. Alan Hatton, Professor Ulrich Suter and Professor Monty Alger.

FACULTY

Professor John L. Anderson, Visiting Professor, has been with us this past year on sabbatical leave from Carnegie-Mellon University. He received the following awards: Fellow of the John Simon Guggenheim Memorial Foundation and Institute Lecturer, University College, Dublin, Ireland. Professor Anderson gave invited seminars and lectures at MIT, Johns Hopkins University, Exxon Research and Development (Baton Rouge), Exxon Research and Engineering (Linden), Brown University, NASA (Marshall Flight Center), University of Michigan, Cambridge University (England), University College (Dublin), Imperial College (London), Institut Francais du Petrole (Paris), and Centre de Recherches sur les

Macromolecules (CNRS, Strasbourg). Professor Anderson also presented a paper at the American Chemical Society (ACS) Meeting in Kansas City, four papers at the AIChE Annual Meeting in Los Angeles and organized a 1 1/2 day symposium held at the ACS Meeting in Washington, D.C. He has seven manuscripts submitted and accepted for publication in archival journals and has been appointed Head of Chemical Engineering at Carnegie-Mellon University, effective September 1, 1983.

Professor Robert C. Armstrong gave invited lectures at the University of Massachusetts, the University of Kansas, Virginia Polytechnic Institute, ARCO Chemical Company, and Kodak. In addition, he presented papers at the Society of Rheology meeting in Evanston, IL and at IUPAC meetings in Athens, Greece and Amherst, MA. Professor Armstrong continues to serve as Assistant Editor of the Journal of Rheology and as a member of the working party on Structure and Properties of Commercial Polymers. He also served as co-chairman with Professor Brown of the organizing committee for the Third International Workshop on Numerical Simulation of Viscoelastic Flow.

Professor Janos Beér served on the Joint Committee (Board of Directors) of the International Flame Research Foundation as the Foundation's Superintendent of Research and also continued his membership of the Science Advisory Board of the Italian National Research Council. He was reelected as a Member of the Board of Directors of the Combustion Institute, served on a DOE Advisory Committee to review the DOE's coal combustion research program, and on the Executive Committee of the 7th International Conference on Fluidized Combustion. Professor Beér also gave invited lectures at Princeton University, Carnegie-Mellon University, and at a Workshop organized jointly by the NSF and the Italian National Research Council on Combustion Research Needs, at the University of Pisa.

Professor John F. Brady gave seminars on rotating disk flow at MIT, the Université Catholique de Louvain, General Electric Company, and the 9th US Congress on Theoretical and Applied Mechanics. He presented a paper on flow development in a porous tube at the AIChE Annual Meeting in Los Angeles, California.

Professor Howard Brenner was elected for a three-year term to the Board of Directors of the Society for Engineering Science and became a founding member of the Board of Directors of the newly organized International Society for PhysicoChemical Hydrodynamics. One of his early papers, "The Diffusional Models of Longitudinal Mixing in Beds of Finite Length" (Chemical Engineering Science, 1962), was cited as a "Citation Classic" in Current Contents: Engineering, Technology and Applied Sciences, having been referred to over 125 times since its original publication. Sessions chaired at professional society symposia included the "Advanced Seminar on the Theory of Dispersed Multiphase Flow" (Mathematics Research Center), "Rheology" at the 28th Macromolecular Symposium (International Union of Pure and Applied Chemistry), "Low Reynolds Number Hydrodynamics" at the 4th International Conference on Physico-Chemical Hydrodynamics (New York Academy of Science), and "Tribology" at the 9th US National Congress of Applied Mechanics, including organizing the latter two sessions. As a member of the Scientific, Editorial and Reviewing Committees of the latter Congress, he was part of the et al. in the symposium volume Pao, Y.H. et al. "Proceedings of the Ninth US National Congress of Applied Mechanics," 518 pp. + xiv, American Society of Mechanical Engineers, 1982. He continues to serve as associate editor of the International Journal of Multiphase Flow, topics editor of PhysicoChemical Hydrodynamics, and holds memberships on the Selection Committee of the Society for Natural Philosophy and the Interfacial Phenomena Committee of the American Institute of Chemical Engineers. New appointments include Co-chairman of the Continuing Program on "Chemical Physics of Colloidal and Interfacial Phenomena" (Colloid and Surface Chemistry Division of the ACS), member of the organizing committee of the 5th International Conference on Physico-Chemical Hydrodynamics (Israel, 1984), Advisory Editor of the new "Butterworth's Series on Chemical Engineering", and Chairman of the forthcoming sessions on "Advances in Materials Science" at the 20th Annual Meeting of the Society of Engineering Science, and the "Statistical Mechanics of Interfaces" at the 76th Annual Meeting of the American Institute of Chemical Engineers, the latter also as organizer. Seminars were presented by Professor Brenner at Harvard, McGill, Illinois Institute of Technology, University of Massachusetts, and Cornell, in addition to lecturing at IBM (Physical Sciences Division, San Jose), GE (Corporate Research Laboratories, Schenectady), and Dow Chemical (Midland). Technical talks and invited lectures were presented at the 4th International Conference on Physico-Chemical Hydrodynamics, the 9th US National Congress of Applied Mechanics, the 28th Macromolecular Symposium of IUPAC, the 54th Annual Meeting of the Society of Rheology and the 75th Annual Meeting of the American Institute of Chemical Engineers.

Professor Robert A. Brown held the Joseph R. Mares Associate Professorship in 1982-1983 and received the Outstanding Faculty Award from the Graduate Students for 1983. He presented invited lectures at Syracuse, Pennsylvania, Princeton, and Lehigh Universities, as well as at Sandia Laboratories, Centre d'Etude Nucleare Grenoble (France), and an Engineering Foundation Conference on Thermosolutal Convection. Professor Brown also served as one of three organizers of the Third International Workshop on Numerical Simulation of Viscoelastic Flows held in Vermont.

Professor Robert E. Cohen was a member of the following Institute-wide committees: the W. R. Grace Biotechnology Steering Committee and CMSE: Internal Advisory Committee including search committee for

new director and developer/implementer of a new Polymer Central Facility. Professor Cohen gave lectures and seminars at Lehigh University, Xerox Corporation, Monsanto Corporation, Mobil Chemical, MIT ILP Polymer Symposium, and at the 1982 AIChE Meeting. He developed, with Professor U. Suter, an expanded version of 10.67 Polymer Science Laboratory to accommodate more students (26 Spring, 1983) and to be given every term. Professor Cohen was appointed co-chairman of the symposium on Multiphase Polymer Systems which will be part of the 1984 International Chemical Congress of Pacific Basin Societies (USA, Canada, Japan joint sponsorship) to be held in Hawaii in 1984.

Professor Clark K. Colton continued as chairman of the Department's Graduate Admissions Committee. He served as consultant to a committee of the Food and Drug Administration concerned with developing standards and pre-market approval of extracorporeal blood processing devices. He continued to serve as associate editor of ASAIO Journal. He gave invited seminars and lectures at the University of Puerto Rico, Howmedica, Inc., The Gordon Conference on Synthetic Membranes, the Third International Congress on Mechanics in Medicine and Biology (Compiegne, France), and the American Society for Artificial Internal Organs annual meeting. His work on artificial pancreas devices was featured in an Associated Press story which appeared in many newspapers, and he appeared on several radio talk shows to discuss his work.

Professor Charles L. Cooney was elected Chairman of the Biotechnology Commission of IUPAC and Chairman of the Fermentation and Biotechnology Division of the American Society for Microbiology. He serves on the editorial boards of Biotechnology Letters, Applied Biochemistry and Biotechnology, Advances in Biochemical Engineering, and CRC Handbook of Bio-Solar Resources. He is also an editor of Biotechnology Advances.

Professor William M. Deen gave invited seminars on membrane transport at Stanford Medical School and the Departments of Chemical Engineering at the University of Florida, Georgia Institute of Technology, and the University of Rochester. He also presented invited papers at the Gordon Research Conference on Water and Solute Exchanges in the Microvasculature (Plymouth, NH), and the ASEE Chemical Engineering Summer School (Santa Barbara) and the International Symposium on Biological Effects of Cationic Proteins (Brussels, Belgium), all dealing with various aspects of transport phenomena in the kidney. Professor Deen chaired a session on Biomedical Transport Phenomena at the AIChE meeting in Los Angeles.

Professor T. Alan Hatton held the Atlantic Richfield Assistant Professorship for 1982-1983. He received the Everett Moore Baker Award for Excellence in Undergraduate Teaching. He gave invited lectures for the Centre for Professional Advancement and at the Central Jersey Section, AIChE 1983 Spring Symposium on Solvent Extraction. He also presented seminars at MIT, Arco Chemical Company, Campbell Soup Company, and Gulf Science and Technology Company. He was co-author of a paper presented at the Joint AIChE/CIESC meeting held in Beijing, China.

Professor Jack B. Howard was elected Chairman of the Fuel Chemistry Division of the ACS. He presented papers at the CIESC/AIChE Joint Meeting in Beijing, China and at the National ACS Meeting in Seattle, and he gave seminars at United Technologies Corporation, Chevron Research Corporation, General Motors Corporation, and Pennsylvania State University. He served as program chairman of the Nineteenth International Combustion Symposium held in Haifa, Israel and as a member of the Program Advisory Committee for the 1983 International Conference on Coal Science. He also served on the visiting committee of the Thermochemical and Electrochemical Research Branch of the Solar Energy Research Institute, DOE. Professor Howard continued as a member of the Editorial Advisory Board of Combustion and Flame and the International Editorial Board of Fuel.

Professor John P. Longwell continues to serve as Executive Officer. He is currently a member of the NASA Propulsion Advisory Committee, the Sandia National Laboratory Advisory Board, and the MIT Press Editorial Board. During the past year he also participated as a member of the ad hoc committee on R&D Test Fuels for the National Research Council. Invited papers include "The Formation of Polycyclic Aromatic Hydrocarbons by Combustion" presented to the 19th Symposium (International) on Combustion in Haifa, Israel and, with Professor Howard, "Formation Mechanisms of PAH and Soot in Flames" at the 7th International Symposium on Polynuclear Aromatic Hydrocarbons in Columbus, Ohio.

Professor Edward W. Merrill received the Alpha Chi Sigma Award at the Annual Meeting of the American Institute of Chemical Engineers in Los Angeles (November, 1982), and was guest lecturer in April, 1983 in a Symposium on Drug Stabilization of Blood Elements at the Harvard Medical School.

Dr. C. Michael Mohr, Senior Lecturer, continued his work in the development of case problems in process design.

Professor Robert C. Reid delivered the plenary lecture on thermodynamics at the first joint AIChE-CIESC meeting held in Beijing, China in the fall of 1982. He also gave the Van Winkle Lecture at the University of Texas, the lead presentation at the Third International Conference on Fluid Properties and Phase Equilibria for Chemical Process Design, and several seminars in other universities.

Professor Adel F. Sarofim presented during the past year a number of technical papers at national and international meetings including the Symposium at the Combustion Institute in Haifa, the EPA Workshop on Research Fundamentals at Southern Pines, North Carolina, the 7th International Symposium on Chemical Reaction Engineering in Boston, Massachusetts, The American Flame Research Committee's Symposium on Combustion in Irvine, California, the EPA-EPRI Symposium on Stationary Combustion Sources in Dallas, Texas, and the annual meeting of the American Association of Atmospheric Research in Baltimore, Maryland. He has also given invited seminars at Johns Hopkins University, Harvard, and the University of Naples, where he held a temporary appointment as Visiting Professor. He served on several advisory committees to the EPA concerned with the incineration of hazardous wastes, the capture of sulfur oxides by limestone injection, and multistage combustion for NO_x control, and a National Academy of Science Committee on the disposal of hazardous waste from laboratories. He continues to serve on the Board of Directors of the American Association of Aerosol Research and is on the advisory editorial boards of Combustion Science and Technology, Progress in Energy and Combustion Science, and Aerosol Science and Technology.

Professor Charles N. Satterfield was the keynote speaker at a symposium in Utrecht, Holland on Production of Energy Carriers and Chemicals from Synthesis Gas, organized by the Catalysis Branch of the Dutch Organization of Pure Scientific Research. He also presented lectures on Fischer-Tropsch synthesis at Rhone-Poulenc, Paris and ANIC-Enichimica, Milan. Papers on recent Fischer-Tropsch research results were given at the 7th International Symposium on Chemical Reaction Engineering, Boston, at the annual AIChE meeting, Los Angeles, and at a DOE Conference on synthetic fuels. He spoke on catalytic hydrogenitrogenation to the Division of Fuel Chemistry, ACS, Pittsburgh, and at a DOE Conference on catalytic hydro-processing. He was chairman, Scientific Advisory Board on Catalysis, American Cyanamid Company. He continued to serve as the chemical engineering member of the advisory board of the ACS, Advances in Chemistry Series, and the ACS Symposium Series.

Professor Herbert H. Sawin gave an invited lecture at Digital Equipment Corporation. He developed a new course on plasma processing for microelectronic fabrication which was taught jointly with the Electrical Engineering and Computer Science Department.

Professor Ulrich W. Suter spent his first full academic year at MIT. He was invited to lecture at the University of Bayreuth, GFR, and at the research facilities of E. I. DuPont de Nemours, Inc. He presented papers at the ACS and AIChE spring meetings and gave a number of talks at seminars outside the Department.

Professor Jefferson Tester continued as the Class of '42 Associate Professor and Director of the School of Chemical Engineering Practice. He presented seminars on various aspects of geothermal reservoir engineering including those given at the Institute and at the General Electric Company, Cornell University, and Los Alamos National Laboratory.

Professor Preetinder S. Virk was invited to lecture at the Illinois Institute of Technology, Chicago. He was co-chairman of symposia on Reaction Pathway fundamentals at two AIChE meetings. He also presented talks on reactor design and cryogenic separations at the Stone & Webster Engineering Corporation.

Professor Daniel I. C. Wang was presented the Marvin J. Johnson Award from the Division of Microbial and Biochemical Technology of the ACS to recognize his outstanding research contributions. He was invited as a plenary lecturer at the 29th International Congress of Pure and Applied Chemistry (IUPAC) in Cologne, Germany. He will serve on the Institute of Food Technologists's Scientific Lectureship Program for 1983-84. He also presented papers, seminars, and chaired sessions at the ACS meeting, NC Biotechnology Workshop, Nutrition Foundation, National University of Singapore, The Biochemical Engineering Conference, RPI, and the International Microbiology Congress. Lastly, he continues to be on the editorial board of Biotechnology and Bioengineering, Comprehensive Biotechnology, and Applied Biochemistry and Bioengineering.

Professor James Wei, Head of the Department, was editor-in-chief of the journal Advances in Chemical Engineering. Volume 12 will appear in 1983. He continued to serve as an editor of the McGraw-Hill Book Series in Chemical Engineering, and on the editorial boards for International Chemical Engineering and Chemical Engineering Communications. Professor Wei has remained active in professional societies. He was the Vice Chairman of the Program Committee and Session Chairman for Synthetic Fuels for the Joint Meeting of American Institute of Chemical Engineers and the Chinese Society of Chemical Technology at Peking which was held in September, 1982. He was chairman of the Seventh International Symposium on Chemical Reaction Engineering held in Boston in October, 1982. He edited the proceedings which was published as a book, Chemical Reaction Engineering - Boston, by the ACS. He is a retiring member of the National Academy of Engineering's Peer Committee for Chemical and Petroleum Engineering and a new member of the Membership Committee. At MIT, he was chairman of the Monsanto Grant Committee. He was elected to the American Academy of Arts and Sciences and to the Academia Sinica of Taiwan, Republic of China. He served on the Presidential Private Sector Survey Task Force on DOE. He will be

listed as one of 29 "eminent chemical engineers" at the Diamond Jubilee meeting of the AIChE in November, 1983. He gave seminars on his research on catalysis at Berkeley, Stanford, California Institute of Technology, University of Michigan, the Catalysis Club of Philadelphia, and the AIChE meeting at Los Angeles.

Professor Glenn C. Williams continued to serve as Graduate Registration Officer for the Department and on the Subcommittee on Graduate Subjects of Instruction of the Committee on Graduate School Policy for the Institute. He also served on the Committee on ROTC and as a member of the Admissions Committee for the Center for Advanced Engineering Science. He is an honorary Director and a member of the Program Committee of The Combustion Institute, on the Editorial Board of Fuel and the Editorial Advisory Board of Combustion and Flame.

STUDENT AWARDS AND HONORS

The American Institute of Chemists Award, given to a senior in chemistry or chemical engineering for demonstrated scholarship, leadership, and character, was given to Douglas Ng. The AIChE Annual Chapter Scholarship Award was awarded to Paul C. Mikesell for maintaining the highest scholastic performance during the first two years of chemical engineering study. The New England Regional AIChE Student Chapter Conference Award was won by Susan D. Flynn in regional competition in April, 1983. Sarah E. Bingman and Harry E. Johnson received the Departmental Special Service Awards for exceptional contributions to the Department's activities. The oldest prize in the Department, the Roger deFriez Hunneman Prize, awarded in recognition of outstanding originality in chemical engineering, was given to Paul C. Mikesell. The Robert T. Haslam Cup, awarded for outstanding professional promise, went to Ivan K. Fong. Also, the Rosemary J. Wojtowicz Memorial Prize was awarded to Jennifer Bistline Corbin for her exemplary performance in Practice School projects. Chevron Corporation awarded two scholarships, covering full tuition, to two juniors who have displayed outstanding academic performance and who exhibit a high degree of professional promise as chemical engineers. This year the scholarships were awarded to Jeffrey L. Collett, Jr. and Richard A. Register. The 1983 Selection Committee of Phi Beta Kappa elected new members in April, 1983 and among those elected were three chemical engineering students, Ali Borhan, Ivan K. Fong and Richard A. Register.

RESEARCH

Combined interdisciplinary and departmental research for which Department faculty were responsible totaled approximately $5.3 million in 1982-83, compared to $5.8 million in 1981-82 and $6.2 million in 1980-81. The research volume generated by the Department alone was approximately $2.3 million compared to $2.0 million in 1981-82 and $1.9 million in 1980-81.

Professor Armstrong has supervised research on fundamentals of non-Newtonian fluid mechanics and applications to polymer processing. In joint research with Professor Brown new understanding has been developed as to the causes of difficulties in computing flows of highly elastic polymeric fluids. Major advances have been made in the elucidation of limit and bifurcation points in these problems and in the development of model test problems for viscoelastic simulators. In other work, research on the rheology of foams and concentrated fiber suspensions has led to improved understanding of the constitutive relations for these multiphase materials.

Professor Beér continued directing research using the MIT Combustion Research Facilities (CRF). The formation of polycyclic aromatic hydrocarbons and soot in coal liquid fuel (SRC-II and EDS) flames were investigated. Detailed flame structure measurements showed the effects of fuel type, mixing, excess air, and heat extraction from the flame upon the pyrolysis of polycyclics in the fuel, the formation of polycyclics by pyrosynthesis, the formation of soot, and upon the decay of these species by interconversion and by oxidation. The conversion of fuel nitrogen in high nitrogen bearing coal liquid fuels in turbulent flames was investigated jointly with Professor Sarofim and Professor Cheng (Mechanical Engineering Department). In the CRF experiments measurements were extended to concentrations of HCN and NH_i species in order to test vigorously mathematical models of fuel-N conversion. Coal-water slurry (CWS) combustion studies were carried out to better understand the processes of flame stabilization, coal particle burn-out, and the transformation of ash in CWS flames leading to the deposition of molten ash on tube walls. Fluidized combustion investigations are carried out using the 500 KW pilot plant fluidized combustor and a laboratory scale fluidized bed (with Professor Sarofim). Professors Sarofim and Beér continued their collaborative investigations of pulverized coal and the pyrolysis of liquid fuel droplet arrays. Measurements of coal particle temperatures by means of time-resolved two color techniques provided insight into details of the processes of coal devolatilization, volatile and char combustion.

Professor Brady continued his research program in suspension mechanics, using a new dynamic method to simulate the behavior of concentrated suspensions. In addition to determining the rheological behavior of suspensions, effort is also directed at dispersive phenomena in these systems. Professor Brady also continued research on the validity of similarity solutions to the Navier-Stokes equations.

Professor Brenner's research focused on rheological properties of spatially and time-periodic suspensions, and on flow and transport processes through spatially periodic capillary models of porous media. He renewed his former interest in ferrofluids and other polarizable suspensions, and studied their unusual rheological and transport properties in rotating systems, especially in conjunction with Professor R. G. Cox (on sabbatical leave from the Department of Applied Mechanics at McGill University). His interests in Taylor dispersion theory led to the invention of a novel chromatographic device based upon flow and sedimentation processes. Modelling of contact-line phenomena, disjoining pressure and other interfacial problems continued to occupy the periphery of his attention.

Professor Brown continued research into the transport phenomena of crystal growth from the melt of semiconductor materials. Progress was made in understanding the operating limits of liquid encapsulated Czochralski growth of GaAs in a project in collaboration with Bell Laboratories and the dynamics of silicon sheet growth for photovoltaic substrates in collaboration with Mobil Tyco Solar Energy Company. Professor Brown also continued studies on the fundamentals of interfacial stability with work focusing on the dynamics and breakup of charged drops. Another study supervised in collaboration with Professor Armstrong dealt with calculation and measurement of viscoelastic flows in complicated geometries. Much effort in the last year focused on the construction of a two-color laser-doppler velociometer for measurement of velocity fields in these flows.

Professor Cohen was co-author of two new patents. One, with Professor Baddour, recently issued on the surface fluorinated polymer products obtained from their previously patented plasma-fluorinated process. A further process patent on UV-assisted surface fluorination of polymers has been filed recently. The second patent, co-authored with several Montedison researchers, involves a novel block copolymer of styrene and propylene. This patent was issued in Italy and is being extended to other countries at present by the Montedison Company. Professor Cohen's collaborative research on heterogeneous polymers, with C. V. Berney, Senior Research Fellow, Chemical Engineering and A. S. Argon, Professor, Mechanical Engineering, has led to a set of structure/property rules for manufacturing tough amorphous polymeric blends and a new understanding of the role of morphological order, interfacial phenomena, chain conformation and thermal stresses in these materials.

Professor Colton continued experimental and theoretical research related to the development of a hybrid artificial pancreas consisting of pancreatic beta cells cultured on the exterior surface of semipermeable tubular membranes, in collaboration with Dr. Andrew Whitemore of the Brigham and Women's Hospital, Harvard Medical School. A study was contained in collaboration with Dr. J. Stuart Soeldner of the Joslin Research Laboratory to develop physiological models of glucose metabolism to permit testing of new forms of insulin therapy for diabetics. Professors Colton and Smith, in collaboration with Professor Michael B. Stemerman of the Beth Israel Hospital, continued research on the transport of low density lipoproteins in the arterial wall. Research was continued to investigate the mechanisms which control filtrate flux and hemolysis in membrane plasmapheresis for continuous separation of plasma from whole blood. Professor Colton initiated a new area of research in the field of applied immunology to investigate the physicochemical properties of immune complexes and their interaction with immunosorbents with application to therapy in neoplastic and autoimmune diseases.

Professor Cooney continued research using alternative feedstocks in biological processes, with special emphasis on the use of C_1 compounds such as syngas for the microbiological conversion to fatty acids and the use of methanol for the production of amino acids. Professor Cooney continued to study the microbiological utilization of lignocellulose, and the use of on-line computers for monitoring and control of fermentation processes such as penicillin, and enzyme production. In collaboration with Professor Langer in the Department of Nutrition and Food Science, studies on degradation of heparin in blood through enzymatic degradation have continued. Work has also been initiated on the separation of biological products such as proteins and chemicals.

Professor Deen continued research dealing with transport processes in the kidney, hindered movement of polyelectrolytes through porous membranes, pharmacokinetics of nitrite and nitrate, and electrochemical processes for fabrication of microstructures.

Professor Hatton continued studies on droplet dynamics and mass transfer interactions in multiphase contactors. He is engaged in the development of a new optical technique for the simultaneous, on-line measurement of local drop size/velocity distributions in dense dispersions. Professor Hatton also initiated study on the effectiveness and potential for scale-up of protein extraction operations using biphasic aqueous polymer solutions. The feasibility of using reverse micellular solubilization of proteins in organic solvents for the separation and concentration of proteins in a liquid surfactant membrane system is also to be investigated. Work is continuing on the mathematical characterization of liquid surfactant membrane processes. In collaboration with Dr. Tom Mix of Merix Corporation, new developments, inspired by liquid membrane technology, are currently under investigation for a variety of defense-related problems by Professor Hatton.

Professor Howard, in collaboration with Dr. W. A. Peters of the MIT Energy Laboratory, continued research on coal pyrolysis and gasification including studies of plastic behavior of bituminous coal,

secondary reactions of primary coal pyrolysis products, and mathematical modeling of mass transfer and reactions in molten coal particles. They also began heat transfer measurements and thermal property determinations in coal, coke, and the coal-to-coke intermediate and, with Professor Longwell, continued research on the thermal conversion of biomass to fuels. Professor Howard continued research on the use of metallized fuel additives to enhance the burnout of soot in flames and, with Professor Longwell, continued studies of polycyclic aromatic hydrocarbons formation in premixed flames and in a well-stirred combustor, including the role of hydrocarbon intermediates in the growth of aromatics in flames and in the surface deposition of material similar to engine deposits.

Professor Kramer is developing a research program in mathematical modeling and optimization, with emphasis on computational methods for large-dimensional chemical engineering systems. In collaboration with Professor Wang, a study of optimal reactor configuration and control for fermentation of cellulose to methanol has been initiated.

Professor Longwell, in collaboration with Dr. Peters of the MIT Energy Laboratory, has been studying the ability of calcium oxide to strongly adsorb aromatics and phenols. Ability to remove aromatics increases with the number of fused rings and at high temperatures these adsorbed species are converted to char. With Professor Sarofim, the catalysis of char gasification by calcium oxide and the deactivation of calcium oxide under cyclic carbonation-decarbonation is also being investigated.

Professor Merrill continued previous studies on scission of macromolecules in dilute solution under conditions relevant to turbulent drag reduction. In studies on heparin fractionation by preparative chromatography with Dr. Elizabeth R. Lang, it was found that one fraction was especially active toward Antithrombin III. Professor Merrill and Professor Hatton established a laboratory course: High Technology Separations with the help of Dr. Lang, in which heparin chromatography was part of the students' assignments. In biomaterials research, particular effort was devoted to surfaces containing polyethylene oxide, because of its very low activity toward blood.

Professor Reid's research interests are in several areas. Under NSF sponsorship, he is continuing his studies in supercritical fluid extraction with emphasis on the design of extractors as well as upon the choice of an appropriate solvent fluid for various applications. With Professor Cooney, he is embarking on studies which will investigate the use of supercritical extractants in continuous fermentation systems. With partial support from the Nestle Company, Ciba-Geigy, and the Arthur D. Little Educational Foundation, the migration of chemical additives from polymer food wraps to food is being investigated. With the use of factor analysis and group contributions, he is also attempting to improve the estimation and correlation of the properties of organic compounds.

Professors Sarofim and Longwell are continuing their research under a long-term grant from Exxon on the combustion and utilization of fossil fuels. The fields of investigation include hydrocarbon reactions, gas-solid reactions, reactor engineering, and the development of experimental tools. The research on hydrocarbon reactions is being conducted jointly with Professor Howard and is described elsewhere in this report. The research on hydrocarbon chemistry complements the research on fuel nitrogen conversion to nitric oxide under fuel rich conditions. The interactions between hydrocarbons and nitric oxide have been studied in a well-stirred reactor. Hydrogen/fuel nitrogen interactions are also being studied under a separate contract from DOE which involves the detailed probing of concentration of stable species temperature, and hydrogen radicals in premixed ethylene/air flames doped with ammonia and nitric oxide.

The study of gas-solid reactions is directed at the gasification reactions of carbon and the capture of sulfur by limestone injection in combustors or gasifiers. The kinetics of the gasification reaction of CO_2 with Montana chars prepared by the devolatilization of coal at different temperatures is being studied in an entrained flow reactor. The interaction of mineral matter with carbon is also being studied from a different perspective by introducing inorganic aerosols into fuel rich hydrocarbon flames and measuring the surface catalyzed carbon deposition. Preliminary measurements with a ferrocene additive indicate that the iron compounds catalyze carbon deposition while undergoing growth by coagulation. The capture of SO_2 by limestone injection into furnaces offers the potential for abating the emissions of acid gases at costs considerably lower than flue gas desulfurization. In order to determine the extents of calcium utilization using different control strategies, the kinetics of oxidation of calcium sulfide, a product of the sulfur capture reaction under fuel rich conditions, and the kinetics of SO_2 capture under fuel lean conditions are being studied. Particular attention is being given by physical transformations since it is found that grain size and porosity are the factors which often control the rates of reaction and extent of reaction.

One study on chemical reaction engineering involves the evaluation of the potential for the use of competitive chemical reactions to characterize the effectiveness of mixing in stirred reactors. Monte-Carlo simulations of the extent of reaction of CO and H_2 using a stochastic mixing model show that the relative rates of reaction of hydrogen and CO are sensitive to the effectiveness of mixing. A second topic being studied in the reaction engineering area is the cyclic calcination and recarbonation of limestone in order to determine the mechanism which reduces CO_2 acceptor activity with time.

Preliminary studies are underway on the cyclic reaction of a single crystal of pure limestone in a thermogravimetric analyzer.

The inability of a thermogravimetric analyzer to measure the kinetics of rapid reactions because of mass transfer limitations provided incentive for the development of a dynamic balance for following reactions of a single levitated particle. Progress has been made in developing a system for rapidly heating, by a laser, a charged particle, 10-100 μm in diameter, suspended in an AC field while measuring its temperature and mass.

Professor Sarofim has continued his studies on the formation of aerosols in combustion systems. During the past year emphasis was placed on the production of sulfuric acid by the catalysis of SO_2 to SO_3 by the inorganic aerosols generated during coal combustion. Parallel studies with Professor Howard involve the characterization of the inorganic aerosols produced during coal combustion, by complementary experimental and theoretical studies of the processes of agglomeration and growth which govern the size distribution of the aerosols.

Professor Satterfield's research on Fischer-Tropsch synthesis has led to several interesting and significant results. The existence of two values of α in the Flory molecular weight distribution, with a break at about C_{10}, has now been demonstrated to exist on a variety of iron-based catalysts. This means that the quantity of liquid fuels and waxes produced is typically double that predicted from the C_{10}-molecular weight distribution, which is that usually reported. The products follow the Flory distribution to molecular weights corresponding to at least C_{100}, as shown by vapor-phase chromatography and H.P. liquid-phase chromatography. In a slurry reactor system the olefin/paraffin ratio of products appears to be higher than for the same catalyst operated in a fixed bed "vapor phase" reactor at the same temperature and pressure. Studies of catalytic hydrodenitrogenation (HDN) of quinoline on a $NiMo/Al_2O_3$ catalyst on a laboratory-scale trickle bed reactor operated at industrial reaction conditions, revealed that small amounts of H_2S and H_2O can markedly accelerate the HDN rate. The presence of H_2S markedly increases the hydrocracking activity of the catalyst while having a slight inhibiting effect on its hydrogenation functionality. A mixture of H_2S and H_2O is more effective than either separately but there appear to be some complex interactions that affect the degree of reversibility of these effects. The presulfiding conditions for optimum HDN activity are more severe than the conditions for optimum hydrodesulfurization activity. Phenolic or cyclic ether compounds either inhibit the HDN rate, by competitive adsorption, or accelerate the HDN rate, caused by the effect of water formed by the hydrodeoxygenation reactions.

Professor Sawin has developed a research program, partially funded by a grant obtained from Digital Equipment Corporation, in reactive ion etching of silicon and silicides for integrated circuit fabrication. His studies center on the kinetics of the surface reactions involved in plasma etching and chemical vapor deposition. The kinetic rate enhancements caused by ion bombardment and the modeling of plasma reactors are of particular interest.

Professor Suter developed a research program for the relationships between molecular structure and polymer properties, and is currently investigating the realm of macroscopic physical properties.

Professor Tester continued his studies of transport phenomena in fractured, porous rock reservoirs used for geothermal energy extraction. Work continued on the interpretation and numerical modeling of fluid mixing and dispersion as measured by tracer techniques. Both one- and two-dimensional models utilizing superposition of mixing in individual fractured zones were successfully developed to simulate field data from tests of prototype hot dry rock geothermal reservoirs located at Fenton Hill, New Mexico and Rosemanowes, Cornwall, England. These efforts are coordinated with those of the staff of Los Alamos National Laboratory operating under the DOE sponsorship and the Camborne School of Mines under U.K. Department of Energy sponsorship. In addition to the tracer dispersion work, Professor Tester has continued studies of the dissolution and reprecipitation of minerals in the fractured, porous rock system at Fenton Hill. A combined program of laboratory kinetic and equilibrium measurements coupled to theoretical and numerical simulation studies was developed to interpret and predict geothermal reservoir performance. Studies of thermally-induced rock spallation were also initiated last year as a potential method of deep drilling. Theoretical, numerical, and bench-scale experimental approaches are being used to determine spallation mechanisms and critical factors affecting penetration rate.

Professor Virk continued his studies of thermal reaction pathways involved in biomass, coal, and petrochemicals processing. The major focus was on the modelling of hydrogen transfer reactions, of which both the kinetics and stereochemistry were experimentally delineated. Frontier-orbital theory, using MNDO-derived descriptions of donor and acceptor MOs, was investigated as a tool for rationalizing and correlating the experiments. He also collaborated with Professor Smith in experimental and theoretical research on the dynamics of LNG storage tank response to atmospheric pressure fluctuations, to enhance the safety of above-ground LNG storage.

Professor Wang continued his research in the utilization of renewable resources for the production of chemicals. He has initiated a new research project to study the mechanism of biopolymer production and

the use of immobilized cells for polymer production. He has also initiated a new research project in the use of recombinant animal cells for the production of human interferon.

Professor Wei conducted research in the kinetics of catalytic hydrodemetallation of heavy oil, in the electrochemical catalytic oxidation of ethyl benzene and butane with Professor Vayenas, in the methanol conversion to olefins and aromatics over the zeolite ZSM-5, in coal gasification reactions and reactors, and in the optimal size of chemical plants under uncertainty.

JAMES WEI

Department of Civil Engineering

During the past academic year, the Department of Civil Engineering continued to develop its educational programs at both the undergraduate and graduate levels and to expand its research program into new areas.

The Department devoted considerable attention and resources to planning its future, more so than in any other year in the recent past. As part of an Institute-wide planning process, the Department produced a "Long Range Plan." The Department's faculty view this plan as a living document, which is part of a continuing planning process. It is intended to help establish directions for the future, but not intended to preclude other new ideas. To quote the introduction to the plan:

"In some ways, this plan is revolutionary; and in some ways, evolutionary. It is revolutionary in that the plan suggests a redeployment of Department resources, through new and replacement faculty and shifts in interests of current faculty into a number of new areas and directions.

- "We plan, through the formation of the Center for Construction Research and Education, to form a partnership between the Department and its natural constituency in the construction industry with programs of education and research. This Center will draw upon the faculty from all technical divisions of the Department and will serve as a major integrating force for many of our activities.

- "We plan to rebuild our faculty strength in the innovative application of computers to problems of engineering design and analyis, strengths that have been largely allowed to atrophy over the past decade.

- "We plan to substantially change the research and educational focus of our transportation activities toward analyis of the problems of private transportation enterprises.

- "We plan to establish a major program in rebuilding and redeveloping America's decaying infrastructure, likely to be the most critical issue the Civil Engineering profession will face over the next decade.

"At the same time, the plan is evolutionary in that many of our new initiatives represent natural progressions of existing activities.

- "We plan to establish major programs in oceanographic engineering, hazardous wastes, and large scale water resource systems development. These programs largely expand on and integrate existing programs in the Department and the Institute to establish new educational and research syntheses.

- "We plan to continue our emphasis in transportation on the development of fundamental methods of tranportation systems analysis, an area in which we have made seminal contributions and which we feel is still fertile.

- "We plan to build upon our current leadership position in risk assessment of engineering systems to take advantage of new opportunities to impact the practice of engineering in this area.

- "We plan a substantial increase in our experimental facilities for studying complex materials behavior, building upon our current analytic strengths in this area.

- "Above all, we plan to continue to build our strengths in the underlying methods and disciplines that are central to Civil Engineering and to evaluate new areas of concentration and areas for potential pruning, so that we can continue to lead in the initiatives described herein.

"We believe that this plan represents a good balance between the 'revolutionary' and 'evolutionary,' and that it represents an approach to the future that is pragmatic and feasible with respect to current Institute constraints."

This report goes on to summarize major departmental activities and faculty/staff honors and accomplishments in this past year.

UNDERGRADUATE PROGRAM

This past year, the Department graduated the first class of 37 seniors that had gone through the restructured undergraduate programs introduced in September 1980. This new program, discussed in detail in the 1980/81 Annual Report, continues to be the cornerstone of our program to raise the level of understanding and appreciation of Civil Engineering among MIT's undergraduates. We continue to have our most effective instructors teaching the sophomore core subjects. The quality of the teaching in these subjects was reflected in high rankings among those subjects evaluated by the Student's Committee on Educational Policy. Professors Robert Whitman, Keith Stolzenbach, Steven Lerman, and David Marks are to be commended for their contribution to this program.

Additional activities include the following:

- The Department had 37 undergraduates participating in the Undergraduate Research Opportunities Program, in areas that span the interests of the faculty.
- The ASCE Student Chapter advised by Professor Amr Azzouz in the fall and Professor John Slater in the spring had a very successful year with a much more ambitious program of activities than in the recent past. This included participation in the regional ASCE Student Chapter meeting at the University of Vermont.
- During the Independent Activities Period, Professor Slater supervised a design contest called "Das Bridge" which attracted (both undergraduate and graduate) students from around the Institute.

The Department continued its active involvement in the Undergraduate Seminar Program offering the following seminars:

Issues in Water Quality	Professor Francois Morel
Visits to Boston Construction Projects	Professor Henry Irwig
Getting from Here to There in Boston: Transportation Planning in the Boston Metropolitan Area	Professors Steven Lerman, Nigel Wilson, George Kocur, and Mr. Thomas Humphrey

Approved during this past year was a restructured undergraduate option in transportation. In addition, the Constructed Facilities Division conducted a substantial review of its junior and senior level undergraduate subjects and plans to recommend a restructured program during this coming academic year.

Early data on course selection by freshmen who entered MIT in September 1982 show some positive signs on undergraduate enrollment for the first time in the past seven years. Hopefully, this turn will continue, helped by changes in economic conditions as well as our specific efforts (as described above) to reach out to the MIT undergraduate population.

GRADUATE PROGRAM

The Department, as in the past, offered graduate programs based in the three Divisions of the Department (Water Resources and Environmental Engineering, Constructed Facilities, and Transportation Systems). This past year, the graduate program in Construction Engineering and Management was administered for the first time by the Department's Center for Construction Research and Education, which was established during the 1981-82 academic year.

The Education Committee of this Center staffed by Professor Clifford Winston (Transportation Systems Division), Professors Erik Vanmarcke, Henry Irwig, and Robert Logcher (Constructed Facilities Division), Mr. Charles Helliwell (Deputy Director of the Center), and chaired by Professor David Marks (Water Resources and Environmental Engineering Division) produced a report entitled, "A Report on Graduate Programs in Construction Engineering and Management," which outlines the future academic initiatives of the Department in the construction field and faculty needs in this area.

New graduate subjects developed this past year include:

- Analytical Methods in Physical Systems by Professor Chiang C. Mei.
- Analysis Methods in Construction Engineering and Management by Professors David Marks, Erik Vanmarcke, and Robert Logcher.

- Transportation and Infrastructure in Developing Countries by Professors Marvin Manheim and Ralph Gakenheimer.

- Analysis and Design of Offshore Structures by Professors S. Shyam Sunder, and J. Kim Vandiver, the latter from the Department of Ocean Engineering.

RESEARCH

The research program in Civil Engineering continues to be a vital component of our overall educational program at both the graduate and undergraduate levels. Funding continues at a healthy level, although volume is down a bit, mostly a reflection of federal policies on research funding. The faculty has responded to this by redoubling efforts to develop research support from the private and international sectors as well as traditional sources of support from federal and state governmental agencies.

As an indication of the breadth of our research activities, projects initiated during this past year include:

Behavior of Friction Piles in Clay

Rock Mass Resistance Studies

Improved Modeling of Ground Motion for Aseismic Design

Statistical Analysis of Precursory Data for Earthquakes Using Physical Models of Fault Mechanics

Finite Element Analysis of Concrete Segmental Bridges Subjected to Seismic Excitation

Reliability Methods for Offshore Structure

Wave-Breaking Forces on Structures

Predicting the New England Red Tide: The Role of Zooplankton Grazing

Stochastic Analysis of Flow in Heterogeneous Rocks

Groundwater Transport Studies

Natural Sources and Biological Sinks of Volatile Halogenated Organic Compounds of the Sea

Wind Mixing in Solar Ponds

Geochemistry of the Bickford Reservoir and Watershed

Mass Transport of Toxic Chemicals Between Bed and Water

Mechanistic Models of Cohesive and Non-cohesive Sediment

Computation of Water Movement in Coastal Salt Marshes

Unified Approach to Performance Standards and Fare Policies for Urban Transit Systems

Improved Methods for Short Range Transit Planning

Load Planning for Trucking Firms

Improving Railroad Productivity

Probabilistic and Economic Factors in Highway Construction and Maintenance

Evaluation of Transportation Construction Project Control Procedures

Energy and Transportation in Developing Countries

Pre-feasibility Study of Gypsum Quarrying and Product Manufacturing in Egypt

Detailed descriptions of all research programs in the Department are available from Department Headquarters for those interested.

FACULTY/STAFF

The following faculty members were promoted during this past year: Dr. Steven Lerman and Dr. Daniele Veneziano were promoted to Full Professor, and Dr. Eduardo Kausel to Tenured Associate Professor.

The Department accepted the resignation of the following faculty members: Dr. C. Allin Cornell, Professor, to conduct a consulting practice and assume adjunct faculty duties at Stanford University; and Dr. Michael Fardis, Associate Professor, to accept a chaired position at the University of Patras in Greece. Also, Ms. Betsy Schumacker resigned from her senior lecturer post to begin a consulting practice.

Dr. John Germaine joined the staff as a Lecturer and Director of the Geotechnical Laboratories. As of this writing, the Department has several ongoing faculty searches in various areas of the Department.

Four members of the faculty were on sabbatical leave. Professor Charles C. Ladd visited geotechnical research facilities in Italy where he gave a series of lectures at the Technical University of Turin, and Norway where he served as a Visiting Senior Scientist at the Norwegian Geotechnical Institute. Professor Marvin Manheim worked on new research initiatives and writing. Professor Oral Buyukozturk worked on new research directions and visited Bosphorous University in Turkey, Delft University in the Netherlands, and Imperial College in England. Professor Rafael Bras, who held a Guggenheim Fellowship, was in residence at Simon Bolivar University in Venezuela during the fall and at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, in the spring.

Professor Gregory Baecher became head of the Constructed Facilities Division on July 1, 1982. He replaced Professor Jerome Connor who served in that post for six years. Professor Connor's contribution to the Department in that capacity is gratefully acknowledged. Professor Baecher joins the two other Division Heads, Professor Lerman of the Transportation Systems Division who was named to his post on July 1, 1981, and Professor Harleman of the Water Resources and Environmental Engineering Division and Parsons Laboratory who has served since 1972.

The Division Heads, together with Professor Fred Moavenzadeh, Director of the Center for Construction Research and Education; Professor Nigel Wilson, Graduate Admissions Officer; Professor Francois Morel, Graduate Officer; Professor David Marks, Undergraduate Officer; Trond Kaalstad, Senior Administrative Officer; and Professor Joseph Sussman, Head of the Department, form the Department Council, which considers matters of Department policy, resource allocation and faculty development, and advises the Department Head on issues facing the Department.

Notable among the honors, recognition, and achievements of the faculty this past year are the following:

Professor Charles C. Ladd was elected to the National Academy of Engineering, the third member of the Department's faculty to be so honored in the last three years. He joins Professors Robert V. Whitman, Donald R.F. Harleman, Peter Eagleson, and T. William Lambe, colleagues in the Department who have been elected in the past.

Professor Lynn Gelhar was named a fellow of the American Geophysical Union, joining Professor Eagleson in this honor. Also, he was the recipient of the Horton Prize of that society joining Professors Eagleson and Bras as members of our faculty who have been so honored in past years.

Two of our faculty published major texts during the past year.

Professor Chiang C. Mei	The Applied Dynamics of Ocean Surface Waves
Professor Erik Vanmarcke	Random Fields: Analysis and Synthesis

The Department continues to encourage our faculty to produce texts of major importance to the field, and we recognize the substantial professional and personal commitment that each such effort represents.

Professor Donald R.F. Harleman received the 1983 Wesley W. Horner Award from the American Society of Civil Engineers for his paper entitled "Evaluation of Selected Initial Dilution Models." He also held a Japan Society of Promotion of Science Fellowship which funded his trip to Japan to confer with colleagues on a number of technical topics, including lake eutrophication.

Professor Erik Vanmarcke gave the keynote address at both the International Conference on Soil Dynamics, Southampton, United Kingdom, July 1982, and the Fourth Canadian Conference on Earthquake Engineering, Vancouver, Canada, June 1983.

Professor Sallie Chisholm was a distinguished Visiting Scholar at the Marine Sciences Research Center at the State University of New York at Stony Brook.

The past year saw the establishment of the Transportation Computing Laboratory, directed by Professor George Kocur. Also, Project ATHENA, a major School of Engineering effort in innovative use of computers in undergraduate education was initiated. Professors Steven Lerman and Robert Logcher are playing important leadership roles in this activity.

The junior faculty of the Department continued to be recognized:

Professor Harold F. Hemond was named the Henry S. Doherty Career Development Associate Professor of Civil Engineering, effective July 1983.

Professor Victor Li was named the Esther and Harold E. Edgerton Assistant Professor of Civil Engineering, effective July 1983.

Professor Henry Irwig was named the Gilbert W. Winslow Career Development Associate Professor of Civil Engineering for the 1982/83 and 1983/84 academic years.

Professor Amr Azzouz, Assistant Professor of Civil Engineering, was the recipient of the Department's award for "Conspicuously Effective Teaching," the first time in the 12 year history of this award that it has been given to a faculty member upon completion of his first year on the faculty.

The professional activities of our faculty and staff continue to be quite extensive with active membership in more than 50 organizations, often in leadership roles, including the following:

- Professor Peter Eagleson is serving as the President of the Hydrology Section of the American Geophysical Union.
- Professor Sallie Chisholm was elected as a Member-at-Large of the American Society of Limnology and Oceanography.
- Professors Mohsen Baligh and Charles C. Ladd are Co-Chairmen of the Advisory Panel for the National Sea Grant Program in Geotechnical Engineering.
- Professor Herbert Einstein is Chairman of the Commission on Swelling Rock of the International Society for Rock Mechanics.
- Professor Robert Logcher is Chairman of the American Society of Civil Engineers' Committee on Engineering Management at the Project Level.
- Professor Yosef Sheffi is Chairman of the Transportation Research Board Subcommittee on Equilibrium Supply Models.
- Professor Erik Vanmarcke is Chairman of the American Society of Civil Engineers' Technical Committee on Seismic Risk and Criteria, and Chairman of the Subcommittee on Risk Assessment of the National Academy of Sciences Committee on Safety of Existing Dams.
- Professor David Marks chaired a National Academy of Sciences Committee on Urban Water Management.
- Mr. Thomas Humphrey was Chairman of the Massachusetts Department of Public Works Transition Team for the incoming administration of Governor Michael Dukakis.
- Mr. Carl Martland is President of the Personal Computers User's Chapter of the Transportation Research Forum.

The following students were recognized:

- Mr. Rodrigo J. Navarro Banzer was the winner of the Richard Lee Russel Award, given to an outstanding senior in Civil Engineering who plans to continue with graduate studies at the Institute. He also was named to Phi Beta Kappa.
- Mr. Koorosh Mozayeny was awarded the Steinberg Prize, given to an undergraduate student for academic achievement and demonstrated interest in construction management.
- Ms. Eftychia M. Nestorides was awarded the Howe-Walker Prize from the Boston Society of Civil Engineers' section of the ASCE.

The Department was pleased to have the following as visiting faculty during the past year:

Professor James Bisogni	Cornell University
Professor Yao Song Chen	Peking University, Peking, Peoples Republic of China
Professor Carlos Daganzo	University of California at Berkeley
Dr. David Hight	Imperial College, London, England
Professor Charles Manski	Hebrew University, Jerusalem, Israel
Professor Edward Petersen	Queen's University, Kingston, Ontario, Canada
Professor Juan Valdes	Universidad Simon Bolivar, Caracas, Venezuela

VISITING COMMITTEE ACTIVITIES

The Corporation Visiting Committee of the Department of Civil Engineering chaired by Dr. Harl P. Aldrich, Jr., met on December 1 and 2, 1982, to discuss issues and opportunities facing the Department. The Committee found the Department to be in good health and effectively positioning itself to participate in the important opportunities and challenges in the Civil Engineering field.

Completing his term as a Visiting Committee member on June 30, 1983, is Dr. Hunter Rouse. The Department wishes to extend its thanks to Dr. Rouse for six years of service on the Visiting Committee.

The Department welcomes the following as new members, all effective July 1, 1982:

Dr. Rolf Eliassen, Chairman of the Board, Metcalf & Eddy, Inc.

Mr. Lester P. Lamm, Deputy Administrator, Federal Highway Administration

Mr. William E. Leonhard, Chairman, President, and Chief Executive Officer, The Parsons Corporation

Mr. E. Kirkbride Miller, Chairman of the Board, T. Rowe Price Associates, Inc.

Dr. James J. Morgan, Vice President, Student Affairs and Professor, Environmental Sciences, California Institute of Technology

Mr. S. S. Olayan, Chairman, The Olayan Group

Mr. David B. Perini, Chairman, Perini Corporation

Coincident with the Visiting Committee Meeting, the Institute dedicated the John R. Freeman Lobby on the second floor of Building 1, at 33 Massachusetts Avenue. John R. Freeman, Class of 1876, is one of the Department's most distinguished alumni. At the dedication ceremony, Chairman Howard W. Johnson called him "one of MIT's all-time great engineers."

His professional career was extraordinary indeed, and included a role in the design and construction of the MIT campus. He was very active in the hydraulics field, and he was chief engineer on the project which converted the lower estuary of the Charles River into a fresh water lake (the Charles River Basin). He also worked in the area of earthquakes; and in 1932, published a textbook on earthquake-resisting design. He twice served as the president of the MIT Alumni Association; a member of the MIT Corporation; president of the Boston Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Society of Civil Engineers.

The Lobby contains a portrait of John R. Freeman and a collection of documents and photographs illustrating his many accomplishments. The memorial was conceived and championed by Dr. Harl P. Aldrich, Jr. Mr. Warren Seamans, Director of the MIT Museum, designed the Lobby.

SEMINARS AND PROGRAMS

The faculty of the Department participated in a number of seminars and programs during the past year. Among the most notable are the following:

The Center for Construction Research and Education conducted a spring semester series entitled, "Opportunities and Challenges Facing the Construction Industry." This series of nine seminars was conducted by distinguished speakers from the public and private sector covering a wide range of topics including infrastructure issues, recent federal legislation, advanced technology in construction, project financing, marketing, and risk assessment.

The Center also sponsored a Roundtable in December 1982 on the redevelopment of America's decaying public works infrastructure. Chaired by the Center's Director, Professor Fred Moavenzadeh, the Roundtable was highlighted by opening remarks by Governor Michael Dukakis of Massachusetts.

The Constructed Facilities Division of the Department sponsored a very well attended series of seminars on the "Status and Directions of Computer-Aided Design." Organized by Professor Robert Logcher, the series covered topics in artificial intelligence, advanced computer graphics, engineering work stations, and implementation issues.

During the Independent Activities Period, the Department sponsored a series of seminars on Computer Applications in Civil Engineering, organized by Professor Clifford Winston.

The Department served as co-sponsor of the BOSS (Behaviour of Offshore Structures) conference held in August 1982, at MIT. Professor Jerome Connor was the chairman of this conference, which attracted an international audience of more than 400 people.

In September 1982, on the occasion of the retirement of Professor J. Melvin Biggs from the faculty, the Department conducted a colloquium to honor Professor Biggs as well as Professors Emeriti Robert J. Hansen and Myle J. Holley. This colloquium, organized by Professor Eduardo Kausel, entitled "Structural Engineering: Research Education and Practice" was attended by distinguished educators, practitioners, and researchers from the United States and abroad and was highlighted by talks presented by Professors Hansen, Holley, and Biggs. Further, the colloquium served as a forum for discussion of future directions in structural engineering at MIT.

Mr. Richard Ravitch, Chairman of the Metropolitan Transportation Authority in New York gave the Tenth James A. Henderson Memorial Lecture in October 1982. His talk entitled, "The Capital Revitalization of a Regional Transportation System: A Case Study of the Metropolitan Transportation Authority" was attended by several hundred people from MIT and the local professional community.

In June 1983, the Department hosted the Federal Emergency Management Agency/United States Geological Survey Workshop on "Continuing Actions to Reduce Losses from Earthquakes in the Northeast United States.

Mr. David McCullough, distinguished author of "The Great Bridge," the story of the Brooklyn Bridge, spoke on this topic at the annual student/faculty dinner on the occasion of the centennial of this great engineering achievement.

In cooperation with the Boston Society of Civil Engineers Section of the ASCE, the Department sponsored the 1982/83 Geotechnical Lecture Series focused on engineering geology.

JOSEPH M. SUSSMAN

Department of Electrical Engineering and Computer Science

In the Fall of 1882, the Institute admitted the first class of students in a new subdivision of Physics called Course VIII-B (Electrical Engineering), which became Course VI in 1884. Accordingly, in October 1982 the Department celebrated the Centennial of Electrical Engineering Education at MIT. The Centennial program included an all-day symposium on Saturday, October 2 on the topic of Lifelong Cooperative Education (LCE), followed by an evening banquet with a program led by "Doc" Edgerton. The next morning witnessed a large number of open houses by various research groups, as well as the showing of numerous films about the Department taken in the past few decades, all capped by an afternoon carnival-style gathering in the Athletic Facility.

The Centennial Celebration was a huge success. It was attended by nearly 1,000 alumni, faculty, students and friends of the Department. Nearly 3,000 copies of the report of the Centennial Study Committee (comprised of Professors Fano, Smullin, Bruce and Siebert) on LCE have been distributed already, and the demand has been so great that we have arranged with McGraw-Hill to distribute about 20,000 additional copies in the coming year.

On the whole, the past year can be described as one in which the Department could barely cope with its success. The number of undergraduate majors grew once again, to 1,116. The sophomore class was at 345 students last Fall. This represents 34 percent of all designated sophomores at MIT. These figures threaten to grow even larger next Fall. Most disturbing is the fact that the high-school senior class that has just accepted admission to MIT contains 15 percent more students who have expressed a preference for a major in EECS than did the previous class.

The number of applicants for graduate admission to the Department also had a substantial increase to 1,685, although the number of openings remained fixed at about 200. The applicant pool was outstanding, and the ratio of acceptances to offers among domestic students rose to 57 percent. Over 4 percent of all students who won NSF fellowships in all fields chose this Department for graduate work. This figure is actually lower than last year, when 5 percent of all NSF winners wanted to study in EECS.

The research volume for the faculty and staff associated with the Department is estimated to have grown approximately 20 percent to well over $30 million. Much of the increase in the past year can be attributed to support from private foundations and industry.

The ratings for EE and CS Departments in the United States appeared last Fall. These ratings gave our EE faculty the highest ranking in the country, above Berkeley and Stanford. Our CS faculty ranked second to Stanford and above third-place CMU. These ratings, we should note, are highly subjective ones. On the other hand, the top three departments in each field have maintained their positions for as long as such ratings have been made.

The process of constructing the "high steel" and the "complex foundation" of the new EG&G Education Center, now dubbed Building 34, created considerable excitement and entertainment in the adjoining EECS Headquarters during the year. The building is scheduled for completion this summer, with a formal dedication to be held on October 7, 1983, the day of the annual meeting of the MIT Corporation.

The capital fund drive for the new Microsystems Technology Laboratories, to be housed in Building 39, stands at about $19 million out of a required total of $21.1 million. The previous occupants (Information Processing Center and Industrial Liaison Program) moved out of the building in May. Renovation work is expected to start in earnest during August, with completion targeted for Fall 1984.

During the last several years our existing facilities have been improved greatly in anticipation of the move, and this past year we received major new industrial research support from the SRC, a consortium of semiconductor companies organized to sponsor university research work in related fields. They have supported our work in three-dimensional integrated -circuit technology, with the expectation that we will become a "center of excellence" in that area. Our research in the microsystems area is now about 15 percent supported by industry and 85 percent by the federal government, which is a very significant change from the recent past.

Educational computing became a major issue during the year. We were shocked to discover that nearly 600 students were in attendance in the first spring-term lecture of our Common Core programming course, 6.001. Our existing computer facilities could only handle the "normal" 300 or so. We were therefore forced to eliminate many freshmen who had intended to take the subject. Fortunately, we have been negotiating for some time with the Hewlett-Packard Company regarding a major gift of their high-performance personal computers for use in 6.001. An agreement was finally reached in the spring for HP to donate 75 of these

computers, valued at $3 million, for use both in 6.001 and in our revised computer architecture subject, 6.004. These machines will be housed in the fifth floor of the new EG&G Education Center. Deliveries of the equipment began in the spring and will be completed in the coming year.

The Department's faculty played a key role in launching Project Athena, a $70 million, five-year effort to explore the use of computing in undergraduate education at MIT. The Digital Equipment Corporation and IBM will give to MIT nearly 3,000 high-performance personal computers, as well as maintenance and additional staff support in the next five years. The bulk of the negotiations leading to the Project were carried out by EECS faculty members: Michael Dertouzos, Director of the Laboratory for Computer Science; Joel Moses, Head of the Department; and Gerald Wilson, Dean of the School of Engineering.

The Department also took a major step this year to implement the LCE concept for its own faculty. We offered the subject 6.001 in a one-week intensive version to 25 of our own faculty in January 1983. The venture was a great success, partly because everyone was housed in a conference center in Norwood, Massachusetts, for the entire week. We are repeating the course in a two-week version in July 1983. This time we shall include faculty in other departments in the School of Engineering as well as representatives from local industry. The course will be taped, and the taped version will be offered in the following two weeks in a Tutored Video Instruction mode to another class of students. Much of the support for the January course came from a fund established by Doug Ross- founder of SofTech, that was announced at the Department's Centennial celebration.

The Department owes a great deal to Professor Peter Elias who spent the last two years as Acting Associate Head for Computer Science and Engineering. Professor Elias, for whom this was the second tour of duty in EECS Headquarters (he was Department Head, 1960-1966), will be taking a well-earned sabbatical this coming year. Replacing him on an "acting" basis will be Professor Fernando J. Corbató, who is no stranger to 38-401, having been Associate Head from 1974 to 1978.

UNDERGRADUATE PROGRAM

Enrollment of undergraduates, which averaged 1,100 in 1982-83, comprised 65 percent in the Electrical Engineering Program and 35 percent in the Computer Science Program. The total represents an increase of about 30 students from the previous year.

With the completion of the EG&G building expected by the end of the summer, 1983, the subject 6.001 Structure and Interpretation of Computer Programs will occupy a major fraction of space in the fifth-floor Electronics Laboratory of the new building beginning in the Fall term. The new subject 6.004 Computation Structures will begin operations in the same laboratory beginning in the Spring term.

The following prizes and awards were won by our students. The Ernst A. Guillemin Prizes for outstanding S.B. theses in the Department were awarded to Jennifer R. Melcher of Lexington, Massachusetts, (first prize), Jean-Jacques J. Hajjar of Beirut, Lebanon (second prize), and John W. Webster III of Detroit, Michigan, (third prize). Honorable mention went to Stuart J. Rubin of Gladwyne, Pennsylvania, Jonathan D. Taft of Somerville, Massachusetts, and Mark A. Burns of Ada, Oklahoma. The William A. Martin Memorial Prize was won by Peter J. Osler of Foxboro, Massachusetts. A Special Departmental Award for Meritorious Service was given to Alex J. Harui of Bainbridge Island, Washington.

The following special scholarships were awarded to our students: the General Motors Scholarship for academic excellence was awarded to Andrew N. Weiss of West Islip, New York; and an Eastman Kodak Scholarship for academic excellence was awarded to Jean F. Moroney of Sanford, Maine.

GRADUATE PROGRAM

In September, 1982, there were 545 graduate students enrolled in the Department. Of this number 197 were newly admitted students. About 20 percent of the total were foreign nationals. The Department supported 190 Research Assistants, 106 Teaching Assistants, and awarded 21 fellowships. In addition, there were 24 National Science Foundation Fellows and 13 Hertz Fellows. The remaining students had industrial or foreign government support or were using their own funds.

During 1982 the Department awarded the following graduate degrees; 157 masters of science, 29 electrical engineers, and 41 doctors of philosophy.

The Department received 1,685 applications for the 1983-84 year, the largest number we have ever had. The applicants were generally excellent and 294 were admitted, of whom we expect 218 to register for next fall.

Graduate students Tom Chu, Mark Colavita, Janice H. Hammond, Michael A. Johnson, and Stuart S. Wagner were given the Frederick C. Hennie III Award for Excellence in Teaching. This award, funded by Proctor and Gamble, is presented to graduate students in the Department of Electrical Engineering and Computer Science

who have demonstrated excellence in teaching. The Carlton E. Tucker Award for Excellence in Teaching was won by Robert H. Enders, and the Harold L. Hazen Award for Excellence in Teaching, funded by an anonymous donor, was won by Robert W. Baldwin. Both awards carried the same citation. In recognition of their excellent performance as teaching assistants Mark Colavita and Stuart S. Wagner were promoted to Instructor-G.

VI-A PROGRAM

The popularity of the VI-A Program took a significant jump this year, when the number of applicants not only rose to the highest in the history of the Program (namely 225) but the percentage of Course VI sophomores applying jumped by 10 percent over previous averages to reach about 62 percent in the spring of 1983.

Surprisingly, too, for a recessionary year, when several of the participating companies decided not to take any new students, the final number of company offerings peaked at 127. To fill these openings the company representatives spent two days on campus in March conducting 1,068 interviews.

The Department is still in a restrictive mode, however, trying to bring the total VI-A enrollment down to a more manageable 250. Consequently the number of new students this year had to be limited to 109; still - though - making this the largest new entering class in VI-A's 67-year history. This is a 48 percent acceptance rate of those that applied and will bring the June 1983 total VI-A enrollment to about 262.

Demand continues to run high amongst companies wishing to join the Program. Due to the Department's restrictive policy, however, the only addition allowed to the Program this year was General Electric's Microelectronics Center at Research Triangle Park in Raleigh/Durham, North Carolina, and this for a position vacated by General Electric's E-Lab's in Syracuse, New York. The MEC took its first three students this June and Professor Stephen D. Senturia will assume the Faculty Advisorship there in January 1984. Director John A. Tucker will act as an interim Advisor in the meantime.

This year also saw a larger number (77) of VI-A's admitted to the graduate phase of the Program. Three received the coveted 'Early Regular Admission' which guarantees financial support, 24 others received 'Regular' admission allowing them to pursue the PhD, while 50 (or 65 percent of those admitted) received restricted admission to the 'SM-only'. Thus 74 percent of the VI-A Seniors (vs 69 percent last year) were allowed to continue on into MIT's Graduate School as of June 1983.

RESEARCH

Most research is performed in departmental or interdepartmental laboratories. Information on their work appears in portions of this report dealing with the following laboratories: the Electric Power Systems Engineering Laboratory (EPSEL), the Research Laboratory of Electronics (RLE), the Laboratory for Computer Science (LCS), the Artificial Intelligence (AI) Laboratory, the Energy Laboratory, the Laboratory for Information and Decision Systems (LIDS), the Operations Research Center (ORC), the Center for Materials Science and Engineering (CMSE), and the Plasma Fusion Center (PFC).

The following research groups are otherwise unaffiliated: Continuum Electromechanics Laboratory, High Voltage Research Laboratory, and MIT Stroboscopic Light Laboratory. Highlights of this year's research from these groups is reported here.

Continuum Electromechanics Laboratory (Professor James R. Melcher)

With the engineering science of continuum electromechanics as an underlying theme, research projects serve widely ranging applications.

Professors J.R. Melcher, T.H. Lee and M. Zahn and their students are researching electrokinetic and electrohydrodynamic processes that have been found to result in the electrical failure of insulating conduits carrying freons. In typical applications, these insulating liquids are applied to the cooling of high voltage equipment. The mechanisms responsible for electrical breakdown have been identified. A method of trapping charge and effectively preventing the sequence of events leading to the breakdown has been found and is currently being subjected to critical experimental and theoretical evaluation. New methods of pumping and sensing the motions of highly insulating liquids have been developed in a line of investigation shedding new light on electrokinetic processes involving generated fields that are on the same order as those internal to double layers.

Professor Melcher and his students are developing experimental techniques and theoretical models for the electrostatic precipitation of fly-ash under dynamic field conditions. Fundamentally, processes involving electrically induced particle migration in the face of turbulent diffusion and electrically induced

convection are of interest. Practically, a class of precipitators that are immune to the electrical properties of the ash are the objective.

Professor Jeffrey H. Lang, in collaboration with Professor David H. Staelin, their students, and the RLE, are developing advanced theories for the identification and control of distributed-parameter systems such as large space structures. This work is being combined with elements of continuum electromechanics in the development of low-mass high-precision electromagnetic reflectors for use in space. Here, electrostatic forces are used to shape the figure of a flexible membrane reflector: closed-loop reflector figure control is necessitated by the membrane flexibility. A five-foot reflector has been constructed and the success of the requisite control system has been demonstrated experimentally. Concurrently, Professor Lang, his students, and the EPSEL are involved in the design of electric vehicle propulsion systems based upon the variable reluctance motor. Models and simulations of the motor and its associated power electronics have been developed to facilitate the optimized design of the propulsion system. Professor Lang and his students are developing special-purpose processors intended to advance this state of digital control system and other signal-processing implementations.

Professor Alan J. Grodzinsky and Dr. Raphael C. Lee and their students study the response of both living and nonliving tissue to various environmental stimuli. These studies provide insight into pathologies such as osteoporosis and osteoarthritis as well as the mechanisms of electrically stimulated bone healing and the effects of electromagnetic radiation on living organisms.

Streaming potentials and the mechanical response of normal and enzymatically degraded cartilage which was electrically or mechanically stimulated have been measured in order to elucidate the nature of the breakdown of the charged molecules. In addition, the synthesis of structural molecules has been assayed in living tissues exposed to similar stimuli.

Another project concerns electric field control of the permeability of charged membranes to neutral or charged solutes. Experiments have shown that an electric field applied across collagen or synthetic gel membranes alters their solute permeability. Optical and mechanical methods are being used to measure real time changes in membrane properties, in order to elucidate the mechanism responsible for electric field induced changes in permeability.

High Voltage Research Laboratory (Professor James R. Melcher)

Professor Markus Zahn and his students have used electro-optical field mapping measurements in highly purified water stressed by high voltages to show significant electric field distortion due to injected space charge. Pulsed power devices, such as inertial confinement fusion machines use water as a dielectric because its high dielectric constant allows large amounts of electric energy to be stored. It also provides a small wave impedance and slow wave speed in transmission lines. Measurements have shown that the polarity and quantity of space charge depend strongly on electrode material, so that with proper choice it is possible to have space charge depend strongly on electrode material. With proper choice it is possible to have space charge free, positive, negative, or bipolar charged water. Generally, space charge has significant effect on the amount of energy stored and on the operating voltage without breakdown.

Dr. Chathan M. Cooke and his students have completed studies on the reliability of compressed-gas insulation used in 200-500 kV electric power transmission apparatus. Failure in these systems is more readily triggered by small perturbations, compared to traditional open-air insulated systems. This greater sensitivity is the result of the desire to make very compact equipment, and hence the need to operate at high electric stresses, nearer the inherent limit of gaseous breakdown. Triggering models and full size experiments were used to establish failure processes involving static charge accumulations on solid insulators, and also involving dust and particles which cause local field enhancements. These results confirmed a sharp transition for triggering versus field distortion or particle size. The study conclusions are being applied to predicting long-term 10 to 40-year insulation life characteristics of practical size apparatus.

In a related study, the homogeneity of high voltage insulation is being investigated by two diagnostics. One, partial discharge emissions measurements, senses minute electric events within an insulation structure long prior to its breakdown. These stress-relieving discharges are measured and analyzed by a computerized pulse analysis system. By timing and size measurements, it is often possible to distinguish the type and location of a partial discharge source, and to evaluate whether or not it is a hazard. The second diagnostic, which employs computerized tomography, is being applied to high resolution imaging of insulators.

Stroboscopic Light Laboratory (Professor Harold E. Edgerton)

The development of a compact, ultra-sensitive underwater television camera system, which will be capable of operation from small boats, continues. The elimination of auxiliary incandescent lighting should provide improved image quality and seeing distance, with drastically reduced power requirements. This

work is supported by the National Geographic Society.

Underwater marine life is being photographed, with a high-speed motion picture camera, by Dr. Gus Paffenhofer (Skidaway Institute of Oceanography) for inclusion in a proposed high-speed movie. Improved electronic flash systems have been developed and used where exposures of less than 0.1 microseconds are required.

Research also continues on the acoustic measurement of height and vertical velocity of aircraft.

Numerous visitors from the Institute, the US, and overseas continue to come to the Strobe Lab for advice.

A seminar on high-speed photography and videography was held (June 20-24, 1983) with participants from around the world. Another is planned for next year.

Research on a bottom penetrating sonar is being conducted, to develop a small, accurate system to be used aboard small boats in shallow water.

Various projects are being pursued in high speed videography.

FACULTY

Faculty promotions this year included Ronald L. Rivest to full professor; and Randall Davis, L. Rafael Reif, and George C. Verghese to associate professor.

Louis B.D. Braida was named Henry Ellis Warren Professor of Electrical Engineering; Robert H. Halstead was designated ITT Career Development Assistant Professor of Computer Technology for two years; Dr. Gerald L. Wilson, dean of the School of Engineering, was appointed first holder of the Vannevar Bush Professorship; Pierre A. Humblet was named Nippon Electric Company Career Development Associate Professor of Computers and Communication for two years; Dr. Thomas H. Lee was designated Philip Sporn Professor of Energy Processing; Nancy A. Lynch was named Ellen Swallow Richards Associate Professor of Computer Science and Engineering for five years; Albert R. Meyer was designated Cecil H. Green Professor of Computer Science and Engineering for one year; Bruce R. Musicus was named the first holder of the Class of 1956 Career Development Assistant Professorship for two years, thus fulfilling the donors' wishes to honor the late Professor Samuel J. Mason; and Charles G. Sodini was named Analog Devices Career Development Assistant Professor.

Joining our faculty this year were Robert C. Berwick, formerly research assistant with the Artificial Intelligence (AI) Laboratory, now assistant professor of Computer Science and Engineering; David K. Gifford, who received his Ph.D. from Stanford University, now an assistant professor of Computer Science and Engineering; Bruce R. Musicus, formerly research assistant in the Research Laboratory of Electronics (RLE) at MIT, now assistant professor of Electrical Engineering; Charles G. Sodini, who received his Ph.D. from the University of California, Berkeley, now assistant professor of Electrical Engineering; and Nancy A. Lynch, previously associate professor of Computer Science at Georgia Institute of Technology, now associate professor of Computer Science and Engineering.

Dr. James D. Bruce, professor of Electrical Engineering and previously director of the Industrial Liaison Program, was named director of Information Systems at MIT; Dr. Mildred S. Dresselhaus, Abby Rockefeller Mauze Professor of Electrical Engineering and Physics, returned to full-time teaching and research after serving as director of the Center for Materials Science and Engineering; Professor Peter Elias returned to teaching and research after serving as acting Associate Department Head for Computer Science and Engineering; he has been replaced as acting Associate Head by Professor Fernando J. Corbató, previously director of Computing and Telecommunication Resources at MIT; Dean Gerald L. Wilson terminated his directorship of the Electric Power Systems Engineering Laboratory (EPSEL), and that position was assumed by Professor Thomas H. Lee. Dr. Lee received the Haraden Pratt Award from the Institute of Electrical and Electronic Engineers; Dr. James R. Melcher, Julius A. Stratton Professor of Electrical Engineering and Physics and director of the High Voltage Laboratory, was named associate director of EPSEL; Dr. Harold E. Edgerton, Institute Professor, Emeritus, received a tribute from the New England Aquarium which established the Edgerton Research Endowment for the support of young scientists in oceanographic research. He was also honored by the Institute when the corridor outside his laboratory was formally named the Harold E. Edgerton Strobe Alley; Dr. Harry C. Gatos, Professor of Molecular Engineering and Electronic Materials, and Dr. Alan L. McWhorter, professor of Electrical Engineering and head of the Solid State Division at Lincoln Laboratory, were elected to the National Academy of Engineering; Dr. Herman Haus, Elihu Thomson Professor of Electrical Engineering, was the recipient of the James R. Killian, Jr. Faculty Achievement Award, and accordingly delivered the 1983 Killian Award lectures; Dr. Erich P. Ippen, professor of Electrical Engineering, received the Edward Longstreth Medal of the Franklin Institute, and was also co-recipient of the 1983 Morris E. Leeds Award for meritorious achievement in the field of Electrical Measurement. Dr. Ippen was elected to the American Academy of Arts and Sciences; Dr. Marvin L. Minsky, MIT Donner Professor of Science in the Department, was selected the 1982 Bendix Innovation Fellow by the Center for Creative

Leadership in Greensboro, North Carolina; Dr. Jerome H. Saltzer, professor of Computer Science and Engineering, was elected a Fellow of the Institute of Electrical and Electronics Engineers for his contributions to the design of large-scale computer operating systems; Dr. William F. Schreiber, Gordon Professor of Electrical Engineering, received the Technical Association of the Graphic Arts Honors Award for outstanding contributions to printing technology and graphic arts science throughout the world; Dr. Peter Szolovits, associate professor of Computer Science and Engineering, received an award from the Graduate Student Council for outstanding teaching in a graduate subject; Dr. John G. Trump, professor of Electrical Engineering, Emeritus, received the gold medal from the American College of Radiology for his pioneering work in the development of megavolt x-ray devices for cancer therapy; Dean Gerald L. Wilson was named by former Governor Edward J. King to be a director of the Massachusetts Technology Park Corporation for a five-year term; Assistant Professor Charles E. Leiserson was the first winner of the Association for Computing Machinery's Doctoral Dissertation Award.

The Department was happy to welcome Visiting Professor Mathukumalli Vidyasagar, on sabbatical for the spring term from the University of Waterloo in Canada, who taught a course and conducted research in System Theory.

Department faculty who were away during the year included: Professor Lawrence S. Frishkopf, on sabbatical leave for fall term; Professor Michael Hammer, on leave of absence for the year to form a consulting firm; Professor Robert S. Kennedy, continuing his one-year leave of absence to conduct research at Lincoln Laboratory on air traffic control; Associate Professor Christos H. Papadimitriou, continuing a two-year leave of absence as visiting professor at the National Technical University of Greece in Athens; and Professor George W. Pratt, on sabbatical for fall term to carry out, in conjunction with MIT, Harvard Medical School, and Tufts School of Veterinary Medicine, research on ultrasound techniques in medicine.

Resignations from the Department included Assistant Professors S. Shankara Sastry and Michael M. Salour, and Associate Professor Christos H. Papadimitriou.

Professor Robert L. Kyhl retired from the Department after twenty-seven years of service.

The Department was saddened by the death of Dr. Alexander Smakula, Professor of Crystal Physics, Emeritus.

JOEL MOSES

Department of Materials Science and Engineering

This has been an important year for the Department. We have looked closely at our strengths and weaknesses, and at national and international needs in our field. We have laid out a Long Range (five year) Plan for the Department and already have made much progress towards realization of that plan.

In formulating our Long Range Plan, we concluded that broad national and international forces, which are only in part technological, are sweeping the center of gravity of our field from its historical foundation in, for example, mineral extraction, steelmaking, and heavy industrial processing. The emphasis is moving instead to the science, processing, and manufacturing of high technology, high value added materials such as electronic materials, structural ceramics, high performance plastics, and metals with radically altered internal structure and properties. We further concluded that to better position ourselves within the field we should act to strengthen our teaching and research programs in electronic materials and in polymeric materials.

To aid in this evolution of the Department we effected a reorganization of the departmental structure, making Electronic Materials a cohesive entity and initiating a degree program at the graduate level in Electronic Materials. We sought and obtained permission to hire two new faculty in this area, and have active searches for both of these faculty underway. Here, as in other parts of the Department, we are vigorously encouraging interaction of our faculty with those in other departments and centers. Specifically, it is expected that both of these new Electronic Materials faculty will interact extensively with the Electrical Engineering and Computer Science faculty, and one with the Magnet Laboratory.

It is clear that the process we have undertaken of building and strengthening the Department can be done only in close coordination with industry, and to this end we have devoted much attention during the year to strengthening our ties with industry - in the form of joint research activities, company- and consortia-sponsored research, special colloquia and lectures, junior faculty, and fellowship support. Much of this industrial interaction is carried on through or in association with the Materials Processing Center, which continues its vigorous growth under the leadership of Professor H. Kent Bowen.

We acknowledge gratefully the wise leadership of Professor Walter S. Owen who, over the last nine years, guided the Department as its Department Head. He was succeeded on September 1, 1982 by Merton C. Flemings. Professor Owen left the Department in a position of strength, ready to capitalize on the great opportunities that lie ahead both for the field of Materials Science and Engineering, and for this Department.

UNDERGRADUATE PROGRAM

A major revision of the undergraduate curriculum, the first in over 10 years, was completed during the last year and will be instituted in the fall of 1983. This revision retains a strong core of materials science and engineering, and has increased emphasis on ceramics, polymerics, and electronic materials. Additional laboratory subjects have also been introduced.

Enrollment in 1982-1983 averaged 122; about 60 percent were enrolled in Course III B, the Department's Cooperative work-study program. The students were placed in 27 different companies. Interest in this program among both companies and students remains at a high level.

The enrollment for 1982-83 is a decrease of 22 from the 144 students registered in 1981-82, reflecting primarily a substantial decrease in the number of sophomores electing to enter the Department. It is quite clear that this decline was because the students perceived that the job market has been poor in the last several years in the basic metals industry, but failed to perceive how great are the needs and opportunities in other areas of Materials Science and Engineering. We therefore took a number of steps to rectify this situation during the last academic year, including the holding of a three day symposium for freshmen and undesignated sophomores entitled "The Electronic Materials Revolution". We anticipate as a result of these steps that our sophomore enrollment in 1983 will be substantially increased over that in 1982.

The following awards and prizes were won by our students: David Burleigh was awarded the John Wulff prize for excellence in teaching. Robert Ashbrook, Kevin Knadle and Allison Sermonte were awarded the Best Senior Thesis prize. Kimberley Elcess was elected to Phi Beta Kappa and Matt Rodammer was awarded the prestigious Goodwin Medal of the Institute for graduate student teaching.

GRADUATE PROGRAM

During the last year we initiated our new graduate program in Electronic Materials, so that we now offer Master and Doctor degrees in six different areas of specialization in the field of Materials Science and Engineering: Ceramics, Electronic Materials, Metallurgy, Polymers, Materials Science and Materials Engineering. We established a graduate "core" of two subjects (one in thermodynamics and one in kinetics) that is now common to all degree programs. As a part of the departmental reorganization, we established a new Graduate Admissions Committee, chaired by Professor Thomas Eagar that has as its major function the admissions process, including finding and attracting the highest quality candidates.

In September 1982 there were 209 graduate students enrolled in the Department. Of this number, 41 were newly admitted students; an additional 26 were admitted in February 1983. Of these students, 55 percent were supported by research assistantships, 10 percent by teaching assistantships, and 25 percent by fellowships. The remainder were using their own funds or were supported by some outside source including foreign governments. Approximately 65 percent of the graduate students are from the United States.

RESEARCH

The Department of Materials Science and Engineering traditionally has been a strong research department and remains so today. Research volume is approximately $11.5 million per year, carried out under individual faculty or groups of faculty. Most research is administered through the Department (58%), the Materials Processing Center (21%), the Center for Materials Science and Engineering (5%), or the Energy Laboratory.

We have major research efforts underway in each of the different classes of materials: ceramics, metals, polymers, and electronic materials. An alternative method for categorizing research activities is without regard to materials classes and is:

MATERIALS SCIENCE	Structure and Transformations	
	Structure/Property Relations	
	Structure/Processing Relations	MATERIALS ENGINEERING
	Property/Performance Relations	
	Process and Systems Modelling	

These five categories include the great majority of research activities now underway in the Department or anticipated to be undertaken. They comprise the essence of Materials Science and Engineering, whether at the scientific or engineering end of the spectrum. A great strength of the Department is that we have programs underway in each of the five categories across many, if not all, of the materials classes. Raising adequate research funds for well-recognized objectives has not in general been a problem for our faculty, and from a departmental standpoint, our strategy is to encourage research programs that (1) most strongly enhance our teaching programs, (2) contribute most effectively to national and societal needs, and (3) otherwise most effectively contribute to our long range objectives.

FACULTY

Faculty promotions this year, to be effective July 1, 1983, included Linn W. Hobbs to full professor and Samuel M. Allen to associate professor. Professor Ioannis Yannas, widely known for his work on artificial skin in the Mechanical Engineering Department at MIT, accepted a joint appointment with our Department and we see this as a first important step in strengthening our polymer teaching and research activities. Dr. David R. Clarke, formerly a member of the technical staff of the Rockwell Science Center, joined the Department as Associate Professor of Ceramics and Glass. Professor Chong Sook P. Sung left the faculty this year and is devoting her full energies to research. Visiting Professor Richard J. Brook from the University of Leeds taught a subject on Fundamentals and Applications of Ceramics Processing, and Visiting Professor Andre Pineau conducted research and taught in the area of Mechanics of Fracture. Visiting Professor Peter MacDougall, University of New South Wales, Kensington, Australia, augmented our research activities in the area of martensitic transformations.

During this year, Professor Harry C. Gatos was elected to the National Academy of Engineering (NAE), bringing the total number of departmental faculty in the Academy to nine. In addition, we have one faculty member (Professor Morris Cohen), who is a member of both the NAE and the National Academy of Science (NAS), and two who are members of NAS.

Professor Cohen was the American Society of Metals/The Metallurgical Society of AIME Distinguished Lecturer in Materials and Society in 1982 and Professor Thomas W. Eagar received the Adams Memorial Membership Award of the American Welding Society. Professor John F. Elliott was made an Honorary Member of AIME. In addition to being elected to the NAE, Professor Gatos received the Edward Goodrich Acheson Award of the Electrochemical Society and the degree of Honorary Doctorate of Science at Indiana University. Professor W. David Kingery received the degree of Honorary Doctorate from the Tokyo Institute of Technology and Professor Ronald M. Latanision was appointed the Shell Distinguished Professor of Materials Science to be effective September 1, 1983. Professor Julian Szekely received the Senior Fellowship Award of the Science and Engineering Research Council, Great Britain for 1983.

We are saddened to note the passing of John Chipman who was Head of this Department for 16 years, from 1946 to 1962. It is given to only a few men, like John Chipman, who were trained in one field, to have a vast influence over another field. Professor Chipman, educated as a physical chemist, created metallurgical thermochemistry and thereby laid the basis for chemical metallurgy as we know it today. The physical chemistry of modern steelmaking, in particular, is based almost entirely on thermodynamic data generated by John Chipman and a succession of his graduate students who have gone on to fill major teaching, research, and development positions in this country and abroad.

Partly because of his technical and scientific leadership, and partly because of the personal qualities of the man, John Chipman left an equally significant legacy as an educator. Under his leadership, the Department of Metallurgy at MIT (later the Department of Materials Science and Engineering) became the most prestigious in the United States if not the world. He saw, earlier than most, the essential unity of metallurgy as a field of study and laid the foundation for the broader synthesis that was yet to come of Materials Science and Engineering.

MERTON C. FLEMINGS

Department of Mechanical Engineering

INTRODUCTION AND PERSPECTIVE

The mechanical engineering profession is broadly concerned with energy, motion and materials, and the design, production and management of systems to meet the needs of society. The profession will have a central role in solving the challenging problems of the 1980's and beyond related to the supply and efficient utilization of energy, manufacturing and productivity, safe and efficient transportation, defense, protection and enhancement of the environment, and health care and human rehabilitation.

Mechanical engineering is based upon a set of basic disciplines in mechanics and dynamics, materials and the thermal-fluid sciences and in the processes of analysis, experimentation and design and manufacturing. The practice of these basic disciplines and processes is changing rapidly due to the increasing capabilities of information processing and real time computation and control technology, the growing ability to synthesize new materials and composites, and improved understanding of the life sciences and human factors. These rapid changes provide both significant challenges and opportunities to the profession and for the education of future engineers.

To meet the demand for mechanical engineering education, the Department has grown substantially in the last decade with increases in undergraduate enrollment from 179 students in 1973 to 408 students in 1983 and in graduate enrollment from 233 students in 1973 to 391 students. The Department has the second largest undergraduate enrollment at MIT. The faculty number has also increased during the decade by 10 percent to 55 in 1983. While the general national economic situation of the past two years has impacted general engineering activity, both student enrollment and demand for our graduates have remained relatively stable during this period. The demand for PhD graduates interested in engineering education, particularly in the design and manufacturing fields, continues to be strong as universities respond to the national educational and research needs in these areas.

Sponsored research conducted by Department faculty and staff has also grown substantially in the last decade by 240 percent to a total level of $17 million in 1983. In the last two years, the total research volume has remained constant with a distribution of one-third of the research administered directly by the Department and two-thirds by interdepartmental laboratories and centers. During the last two years, shifts in areas of support have occurred reflecting federal policy and decreases in support for energy, environmental, and transportation research have occurred, while increases in research support in design and manufacturing have occurred with support for biomedical engineering research remaining relatively constant. While total research volume has remained constant, the increased costs of research and shifts in support have provided a difficult time for several faculty groups.

In the fall of 1982, a study by the National Academy of Sciences rating graduate professional programs at US universities ranked the Department graduate program as first in the nation in mechanical engineering. The Department has been ranked as first in studies published since 1966.

Special emphasis has been placed upon undergraduate laboratory curriculum development this year. Equipment and instrumentation have been upgraded in laboratory subjects and real time control and computation have been introduced into the manufacturing and project laboratories. A five-year plan to coordinate and integrate laboratory education for undergraduates has been formulated which will provide a staged experience starting with basic measurement and instrumentation techniques and leading to real time data acquisition and computer controlled experimentation.

In the graduate program, new subjects have been developed to strengthen the areas of computational fluid mechanics, probabilistic systems, kinematics and design, and manufacturing and robotics.

Faculty effort in identifying and developing new research programs has been notable, particularly in light of the overall support/cost picture. Faculty in the fluid and thermal sciences areas have initiated new programs in computational fluid mechanics and turbulent flows, the thermal-fluid processes controlling growth of electronic materials, energy efficiency in buildings and systems, and biofluid mechanics. Faculty in the mechanics and materials areas have developed new research in metals, fibrous and polymeric materials, and continued major programs in geomaterials and biomaterials. Faculty in manufacturing, design and control have coordinated their efforts in manufacturing process control and robotics and initiated effort in the flexible manufacturing area. Faculty in the biomedical engineering area have extended their research to the initial stages of patient evaluation in cancer treatment using ultrasound, while research to develop artificial skin and to understand the biomechanics of joints and limbs as well as fluid flow in the cardiovascular and pulmonary systems has shown significant progress.

Significant progress has been made in plans to establish several new facilities in teaching and research. Plans for facilities and equipment and fund raising were formulated for the Design Center, a facility for undergraduate and graduate educational and research programs in design incorporating computer-aided engineering equipment. The REMERGENCE Facility for resource extraction (oil, gas, coal), geotechnical and construction engineering, which is a joint facility with Civil Engineering, has been established with new laboratory testing capability. The effort to develop a Center for Energy Efficient Buildings and Systems jointly with the Department of Architecture has progressed with the establishment of a laboratory facility for scale model evaluation of building systems.

In September of 1982, Professor Herbert H. Richardson resigned as Department Head to accept an appointment as Associate Dean of Engineering. Professor Richardson served as Department Head for eight years, during which time the Department had significant growth. His leadership and vision during this period have been deeply appreciated by the faculty. Professor David N. Wormley, a member of the Department faculty since 1967, was appointed as Department Head in September.

PROGRAMS OF INSTRUCTION

Objectives

The primary objectives of the Department instructional programs are to educate mechanical engineers for leadership roles in professional practice and engineering education, and to provide a broad and flexible background for entering related fields such as medicine, law, management, and public policy. Programs emphasize a basic foundation in the engineering sciences combined with a strong design orientation and practical laboratory experience which couples theory and analysis with the physical world. At both the undergraduate and graduate levels, involvement of students with faculty research at the forefront of engineering practice--through special projects, the Undergraduate Research Opportunities Program (UROP) and theses--is a hallmark of the Department.

UNDERGRADUATE PROGRAMS

Degree Program and Enrollment

The Department undergraduate program leads to the SB in Mechanical Engineering (Course II), which is accredited by the Accreditation Board for Engineering and Technology (ABET) or the SB without specification (Course II-A), which is non-accredited. Course II-B, the Engineering Internship Program, leads to the SB and SM in Mechanical Engineering with industrial experience an integral part of the program.

The Department enrollment, which in the 1970's had grown significantly to stabilize at around 400 undergraduates, continued in 1982-83 at a level of 408 students. The new sophomore class of 130 included 31 women, 23 percent of the class, and nine black students. Approximately 14 percent of the class are minorities--7.6 percent black, 1.4 percent Hispanics, 5.3 percent Asian-Americans, and 0.8 percent Native Americans.

Course II-A provides an alternate to the regular mechanical engineering program and is intended for those students who want to design an interdisciplinary program with substance in some other field (e.g., biomedical engineering, management, energy policy, materials) as well as in mechanical engineering. About 35 students were enrolled in II-A.

The Department has been heavily involved in the School of Engineering Internship Program since its inception in 1977-78. This past year, out of a total of 41 sophomores from seven departments who were placed in 36 companies, 22 were Mechanical Engineering students. Currently the Department has 46 students in the Program out of a total of 104: eight graduate students, 16 seniors and 22 juniors.

In 1982-83 the Department awarded 126 SB degrees (111 in Mechanical Engineering, 11 without specification, and four in II-B). Twenty-nine women (six black) and six black men were among the degree recipients.

Undergraduate Curriculum Development

The Department Academic Policy Committee, chaired by Professor Joseph L. Smith, Jr., developed a strategy for long range curriculum revision to enhance the intellectual content of engineering and instructional activity utilizing advanced computational techniques. The Committee has broadly scoped the development activity into (1) development of an integrated laboratory sequence starting with an introduction of instrumentation and measurement and leading to computer-aided data acquisition and content of experiments, (2) an increased coupling of analysis and design, and (3) a strengthening of the basic disciplinary subjects with improved computational techniques. This initial curriculum revision plan will be refined in the next academic year.

Undergraduate instrumentation and materials laboratories were improved with the addition of basic measurement equipment and direct digital data acquisition techniques were developed by Professor William C. Unkel for 2.672 Projects Laboratory.

The subject 2.86 Manufacturing Processes has been revised with the introduction of new material in the areas of metal processing, polymer processing, process control and automation. A new laboratory employing digital computer control of manufacturing processes has been developed by Professor Ming K. Tse. Preparation of a new textbook in manufacturing has been started by nine faculty with Professors Nathan H. Cook and Nam P. Suh providing editorial review.

Student Organizations

The Student Chapter of the American Society of Mechanical Engineers (ASME) under the leadership of its officers: Theresa A. Sutton, President; R. Mark Fenton, Vice President; Lee F. Mallett, Treasurer; and Diane P. Karalekas, Secretary, continued with a membership of 170 students. Professor Bruce M. Kramer remains as Faculty Advisor. In 1982-83 lunchtime ASME meetings replaced the late afternoon meetings of the past years. These popular meetings included standing-room-only lectures by Professors David Gordon Wilson and Thomas P. Bligh.

Black ME is an organization of black students which provides a supportive environment for minorities in the Department. Activities included updating the organization's library of course notes, and hosting a Freshman/Faculty dinner. Total membership for the year was 48. The Faculty Advisor continues to be Professor Stephen H. Crandall, and the officers were: Lisa Washington, President; Melanie Park, Vice President; Cheryl Whiteman, Secretary; and Karen Ball, Lounge Officer.

Pi Tau Sigma, the mechanical engineering honorary society, continued its tradition of fostering student-faculty relations and serving the Department through its Course and Instructor Evaluation Program. Among the social events sponsored were a fall cookout with ASME, tri-weekly social hours, and a spring banquet at Endicott House. Black ME, ASME and Pi Tau Sigma combined efforts to help with the Department's Freshman Open House. The Faculty Advisor continues to be Professor Warren P. Seering, and the officers elected in the spring are: Lee F. Mallett, President; Beverly G. Farris, Vice President; Mia (Maria L.) Paget, Treasurer; and Deborah A. Summa, Secretary.

Student Awards

Many undergraduates in the Department were recognized for academic and athletic excellence, engineering creativity and community service.

Two seniors received scholarship. Thomas M. Stepien received an Alpha Tau Omega Foundation scholarship. Greg A. McAllister was selected the winner of the Henry Ford II Scholar Award, given annually to a student on the basis of an outstanding academic record.

Three sophomores received industrial scholarships: Michael J. Ambrogi was selected as Eastman Kodak Scholar and Margaret A. Norris and Rita R. Edmonds were selected as General Motors Scholars.

David W. Cooke was elected to Phi Beta Kappa.

Cindy M. Pribble received a Karl Taylor Compton Prize. These prizes are the highest awards given to students by MIT and are for lasting contributions to the MIT community. Rodney B. Sherman and Theresa A. Sutton received William L. Stewart, Jr. awards for outstanding contributions to the MIT community. Theresa also received the ASME Outstanding Student Certificate and the Department Student Service Award.

Brian D. Jacobs received the James H. Killian, Jr. Community Service Award and Lisa A. Washington received honorable mention for the 1983 Association of MIT Alumnae Senior Academic Award. Mark P. Bouchard won a Scott Paper Award.

Three students won athletic awards: Theresa A. Sutton, the Pewter Bowl Award; Anella E. Munro, the Betsy Schumacker Award; and John D. Busa, the Admiral Edward L. Cochrane Award.

GRADUATE PROGRAMS

Degrees

The Department offers the SM in Mechanical Engineering, the undesignated SM, the degree of Mechanical Engineer, and the doctorate in Mechanical Engineering. The undesignated SM allows students freedom to design special interdisciplinary programs with thesis research done in the Department, while the Mechanical Engineer program is intended as an alternative to the doctoral program for students who wish to emphasize applications and/or design, including economic and social aspects.

Enrollment and Degrees Granted

Graduate enrollment decreased slightly in 1982-83 to 391. In the fall of 1982 there were 25 women, three blacks, eight Hispanics (one woman), and 14 Asian-Americans. In September 1982, 674 applications were received, an increase of 14.6 percent from the previous year. In the fall of 1982, 381 were admitted and 164 registered. This is a drop in acceptance from 1981 when 351 were admitted and 178 registered. Of the new students, 24 percent are foreign.

In 1982-83 the Department awarded 147 SM degrees (of which 18 were combined SB/SM degrees), five Mechanical Engineer, and 27 doctoral degrees, a total of 179 degrees compared to 139 the previous year.

In 1982-83, 54.7 percent of the graduate students were supported by the Department through research and teaching assistantships, 10 percent higher than in the previous two years. Overall, about 88 percent of all graduate students received support from the Department, MIT funds, fellowships, the government or industry, slightly higher than the 85 percent in 1981-82.

Graduate Subject Development

Four new subjects have been developed in the graduate program and several subjects have been significantly modified.

2.05 Kinematics and Dynamics of Mechanisms and Manipulators (A) is a new subject developed by Professor Steven Dubowsky to be offered for the first time in the fall of 1983. The subject will present fundamental principles and analytical techniques for the analysis of the kinematics and dynamics of behavior of mechanisms, machines, and manipulators.

2.274 Computational Fluid Dynamics is a new subject developed by Professor Anthony T. Patera, which will be given for the first time in the fall 1983.

Professor Haruhiko Asada, with Professors Dubowsky and Neville J. Hogan, has developed 2.835 Design and Analysis of Robotic Manipulators (A). The subject will present principles from the fields of kinematics, dynamics, system modeling, control theory and computers required for a basic understanding of the theory and design of computer controlled machine systems, with applications drawn from industrial robot manipulators.

Dr. David G. Jansson and Professors Woodie C. Flowers and Seering have developed 2.944 The Idea/Product Transformation, which will be offered for the first time in spring 1984. This project-centered subject will address the transformation of new ideas into technology-based products, attaining a proper match between product and marketplace from the perspective of both source and customer.

Professor Hogan revised his undergraduate subject 2.04 Probabilistic Modeling and Analysis of Engineering Systems into a graduate (A) subject to be offered for the first time in spring 1984. The purpose of the subject is to provide mechanical engineering students with techniques necessary to treat uncertainties in the mechanical engineering context.

Professor Tau-Yi Toong has completed a text Combustion Dynamics - The Dynamics of Chemically Reacting Fluids, McGraw-Hill, New York, 1983 for use in the subjects 2.281 Reacting Gas Dynamics and 2.282 Combustion.

In the spring of 1984, Professor Myron Tribus, of the Center for Advanced Engineering Study, will offer 2.842 Managing Systems of People and Machines for Quality and Productivity (A). The subject covers application of statistical and managerial principles to processes involving systems of people and machines and the relation between quality of process and system productivity.

Student Awards

Luu T. Nguyen won a Karl Taylor Compton Prize for exceptional Institute service, and Stuart B. Brown won a Department Student Service Award.

Dr. Subramanian Suresh, who received his ScD from the Department in 1981, was awarded the Robert Lansing Hardy Gold Medal Award from the Metallurgical Society of the American Association of Mining, Metallurgical and Petroleum Engineers. In addition, Dr. Suresh and his thesis supervisor, Professor Robert O. Ritchie (now at Berkeley) were co-winners of the Department of Energy award for the 1982 Most Outstanding Scientific Accomplishment in Metallurgy and Ceramics. These awards were given for research performed while Professor Ritchie and Dr. Suresh were in the Department.

RESEARCH

Support Level and Distribution

The total volume of sponsored research for 1982-1983 is estimated at $17 million, essentially the same level as last year and representing approximately $290,000 per faculty member. This year approximately one-third of the research has been administered through the Department and two-thirds through inter-departmental laboratories and centers.

The Department sources of research support are derived from a wide spectrum of government agencies and industries. In the last few years the portion of research supported by industry administered through the Department has increased significantly from 12 percent in 1981 to approximately 25 percent in 1982-1983. Several laboratory groups derived 50 percent or more of their support from industry including the resource extraction activity in the REMERGENCE Facility, the Innovation Center, Laboratory for Mining Systems Development, Laboratory for Manufacturing and Productivity and the Computer-Aided Design Laboratory. Several of the government sources of funding have been reduced in the last two years including support from the Department of Energy, the Department of Transportation and the Environmental Protection Agency. Reductions in a number of areas supported by these agencies have resulted in some interruption of research by students and faculty and led to redirection of effort by several research groups.

Several companies and foundations continued to provide grants of unrestricted funds to the Department and funds to support the career development of young faculty. These discretionary funds have been used as seed funds to initiate new research areas, to enhance the development of young faculty careers and to acquire initial equipment for education and research. Several young faculty are supported this year by the TRW Foundation faculty fellowship, the IBM Grant based on excellence in materials and manufacturing research, the Du Pont Engineering Grant and Faculty Fellowship, and the Rockwell International Assistant Professor Fellowship. These grants have provided significant assistance in initiating research activities by several young faculty.

Research in the Department varies from basic fundamental research to the conception, design and prototype evaluation of innovative systems to serve the needs of society. Approximately half of the faculty is explicitly involved in basic research and almost every research project in the Department has a component of fundamental research. In research applications the fraction of faculty involved in the four major application areas are: manufacturing, materials, and processing, 35 percent; energy and environment, 45 percent; biomedical engineering, 22 percent; and systems including transportation, 18 percent.

Research Accomplishments

In biomedical engineering significant progress has been in research related to human mobility and sensory aids, treatment of tumors via hyperthermia, artificial skin and biofluid mechanics.

In the Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation, a unique capability has been developed for research in mobility, joint mechanics, and movement control. Professor Robert W. Mann and his students have developed the TRACK system for measuring body-segment kinematics and the foot-floor interaction of moving humans and have further developed techniques to determine joint forces and moments. This system has provided a basis for an improved understanding of normal and pathological human gait and muscle action including knee and ankle joints. Studies conducted in the Laboratory by Professor Flowers have led to development of a microprocessor-based biofeedback and gait analyses system for training above-knee amputees in use of prostheses. This system has been evaluated with encouraging results in the Laboratory.

A new initiative in the Laboratory by Professor Mann is investigating the use of computer-aided-surgery simulation to aid surgeons.

Research to develop a biocompatible artificial skin conducted by Professor Ioannis V. Yannas and his collaborator Dr. John F. Burke has led to clinical evaluation of skin produced for over 40 severely burned patients. Results have been encouraging and led to development of a new stage 2 artificial skin, which induces wound tissue to regenerate a new epidermis over a large area of the wound. Clinical trials of the stage 2 skin are planned.

Professor Padmakar P. Lele, in the Laboratory for Medical Ultrasonics, has achieved encouraging results in reduction of tumors through controlled hyperthermia using focused ultrasound. Plans have been completed to move his laboratory in the summer of 1983 to a clinical setting so that extensive patient treatment may be performed.

Professors Roger D. Kamm and Ascher H. Shapiro, in the Fluid Mechanics Laboratory, have continued their basic studies of pulmonary ventilation and have initiated research on the hydrodynamics of acqueous solutions related to eye diseases such as glaucoma. Their research is directed to an improved understanding of the factors causing elevated pressure to provide improved techniques for diagnosis and treatment. Also in the Fluids Mechanics Laboratory, Professor C. Forbes Dewey, Jr.'s studies on the genesis of arteriosclerosis have resulted in experimental quantification of the threshold levels of shear stress required to align endothelium cells which line the artery wall with the blood flow.

The Department's major activities in manufacturing and processing are associated with the Laboratory for Manufacturing and Productivity. This interdepartmental Laboratory, which has grown substantially under the leadership of Professor Suh, involves faculty from the Department in major program areas of computer-aided manufacturing, metals processing, polymer processing, flexible materials, and tribology. In the last year new research in automated welding has been initiated by Professor David E. Hardt. The robotics activities of Professors Hogan, Asada, Seering, and Dubowsky have been coordinated and consolidated in new laboratory space and have continued to benefit from close association with the Artificial Intelligence Laboratory. The tenth year anniversary of the MIT-Industry Polymer Processing Program involving Professors Suh, Lewis Erwin, Timothy G. P. Gutowski, and Tse will be marked by a special symposium in the summer of 1983 to explore innovative polymer processing techniques for the next decade. In metal processing research, Professor Kramer, in experimental research, has identified the limiting factors influencing tool wear in machining titanium. A new initiative in the tribology area has been started with Professor Ernest Rabinowicz to establish an industrial consortium to support basic and applied research in problems of wear and developing new materials and composites which will significantly reduce wear. New research programs in flexible materials, including textile materials, have been developed by Professors Stanley Backer and James H. Williams, Jr.

The Machine Dynamics Laboratory has provided a facility to coordinate research in the kinematics, dynamics, and control of machines for the research of Professors Richard H. Lyon, Seering, Hogan, James E. Hubbard, Jr., and Dubowsky. In the last year, the activity has grown considerably with projects in automation, acoustic diagnostics, and machine performance.

In the mechanics and materials area, several fundamental research programs achieved significant results in advancing analysis/numerical techniques and improving the understanding of materials behavior. Professor Klaus-Jürgen Bathe has extended finite element techniques to the analysis of fluid-structure interaction problems, while Professor David M. Parks has advanced the development of finite element techniques for fracture mechanics analysis. Basic experimental research to characterize the properties of metallic glasses has been performed by Professor Ali S. Argon and research has been initiated by Professor Lallit Anand to develop constitutive equations for high temperature deformation of metals. Professor Williams evaluated acoustic emission techniques to the nondestructive evaluation of fiber composites. A project to predict fatigue life of large turbine shafts was completed by Professor Frank A. McClintock. Professor Stephen H. Crandall extended his analytical studies of rotor-shaft dynamics.

The area of energy and environment involves about half of the Department faculty. During the year progress was made in several relatively new programs in energy conservation in buildings, resource extraction, heat transfer in electronic materials, and combustion and lubrication in internal combustion engines. During the past year, laboratory space was acquired and experiments initiated in energy conservation in buildings, a research program conducted by Dr. Leon R. Glicksman and Professors Bligh and Maher A. El-Masri with the Department of Architecture. This new research initiative to develop technologies for energy efficient buildings includes plans for development of a scale model building laboratory facility.

Plans for a joint Mechanical/Civil Engineering facility for experimental work in resource extraction, geotechnical and construction engineering have been formulated in detail with respect to space, laboratory equipment, and fund raising. Professors Michael P. Cleary and Herbert H. Einstein are providing leadership in this activity respectively from the Departments of Mechanical and Civil Engineering.

The initiative to develop a Laboratory for Mining Systems Development has been pursued by Professor Carl R. Peterson. A collaboration with Pennsylvania State University faculty has been established to broaden and strengthen the research effort.

An initiative in the Heat Transfer Laboratory by Professors Borivoje B. Mikic and Anthony T. Patera to develop research in the processes controlling electronic material quality has led to a project conducted in cooperation with the Departments of Materials Science and Engineering and Electrical Engineering and Computer Science in defining factors influencing material quality during crystal growth.

An initiative in the Sloan Automotive Laboratory has been undertaken to form an industrial consortium to support research in the uses of ceramic materials in engines. This effort involves Professors John B. Heywood and Wai K. Cheng and Drs. David P. Hoult and Agop Ekchian. In the Laboratory Professor James C. Keck continued basic combustion research.

Experimental studies to characterize two phase gas-liquid flows in power systems have been conducted by Professor Peter Griffith and his students. In complementary research, Professor Wilson is characterizing two phase flows in centrifugal pumps.

In the Cryogenics Engineering Laboratory Professor Smith and colleagues from the Electric Power Systems Engineering Laboratory made significant progress in construction of a prototype super-conducting generator.

Professor Smith and Dr. Yukikazu Iwasa also initiated cryogenics research conducted jointly with the Francis Bitter National Magnet Laboratory. A major experimental facility was completed to characterize power plant air/gas dynamics in research conducted by Professors David N. Wormley and Derek Rowell.

A number of fundamental research studies in the energy and environmental area have been conducted this last year which are of special significance. A basic research effort in experimental, analytical, and numerical techniques to characterize pressure fluctuations in turbulent boundary layers has been initiated under the leadership of Professors Patrick Leehey, Patera, and Triantaphyllos Akylas in cooperation with Professor Steven A. Orszag, of the Department of Mathematics. Fundamental research in the quantum mechanics foundations of thermodynamics has been continued by Professors Gian P. Beretta and Elias P. Gyftopoulos. Professor James A. Fay has continued basic studies of the dispersion characteristics of dense gases in the atmosphere with application to liquid natural gas vapor clouds. Professor Toong has continued fundamental studies of turbulent flame propagation. Basic research to characterize heat transfer in film boiling was conducted by Professor Warren M. Rohsenow.

In systems and transportation, research is concentrated in four areas - the Man-Machine Systems Laboratory, the Computer-Aided Design Laboratory, Transportation Technology, and the Innovation Center. Professor Thomas B. Sheridan and Dr. Dana R. Yoerger of the Man-Machine Systems Laboratory have made significant progress in undersea remote manipulation with the establishment of an experimental test capability to evaluate and modify an undersea manipulator. Through this research, stronger ties to the Woods Hole Oceanographic Institute have developed. Research in the Laboratory has also been directed to developing a theoretical foundation for man-machine supervisory control.

Professor David C. Gossard and his associates in the Computer-Aided Design Laboratory have developed automatic scaling techniques for mechanical assemblies that allow scaling to be performed on a basis of designer-prescribed constraints and objective functions. This research is complemented by studies specifically directed to developing a designer-machine interface that enhances iterative design interaction.

In transportation technology, Professor Hubbard, in collaboration with Professor Wesley L. Harris of the Department of Aeronautics and Astronautics, has developed experimental and analytical techniques to optimize helicopter blade performance so that far field noise generation is reduced. Professor J. Karl Hedrick in the Vehicle Dynamics Laboratory has developed a laboratory model prototype active suspension unit for use in controlling the lateral dynamics of AMTRAK passenger cars. After laboratory testing, initial field testing is planned. Professor Paul K. Houpt completed a study of internal combustion engine control systems in which novel methods of detecting changes in air-fuel mixtures using cylinder pressure measurements have been developed.

The Innovation Center continued to expand its research program base, under the leadership of Dr. Jansson, undertaking projects involving students in innovative product development for industrial clients.

FACULTY AND STAFF

Size and Composition

On July 1, 1982 there were 59 active faculty: 29 professors, 16 associate professors (five with tenure), and 14 assistant professors. During the year two professors were transferred to the Dean of Engineering's rank list, and two associate professors resigned. On July 1, 1983 one assistant professor will join the Department and result in 56 active faculty members.

Nine faculty are minority group members: two black (a professor and an assistant professor) and seven Asians. A woman associate professor resigned in February. The teaching, research, and technical staff fluctuates at around 70, more than half of whom are part-time people whose principal base is either in another department or outside MIT; many of these part-time individuals serve without stipend. Among this staff are six Asians, one Hispanic, three women. Of the six administrative staff, four are women and of the 34 support staff, one is a man and two of the women are black. The Department has 17 hourly staff, three of them blacks.

Notable Accomplishments and Awards

Three faculty were appointed to chairs: Professor Ali S. Argon was appointed to the new Quentin Berg Professorship in Mechanical Engineering. This chair was established by Mrs. Berg in memory of her late husband as a permanent tribute to his career and accomplishments. Professor Anthony T. Patera received a three-year Rockwell International Professorship which is designated to assist young faculty in professional development. Professor Lallit Anand was appointed to the Esther and Harold E. Edgerton Professorship for two years. The objective of Edgerton professorships, which were established to honor Institute Professor Emeritus Edgerton, is to support young faculty and to provide funds to involve undergraduates in their research activities.

Professor Steven Dubowsky received a Best Paper Award from the ASME Mechanisms Committee for a paper presented at the 1982 ASME Technical Conference.

Professor Lewis Erwin received two Best Paper Awards at the 1982 Annual Conference of the Society of Plastics Engineers: one for the best extrusion paper and one for the best thermoset paper.

Professor Woodie C. Flowers received the 1982 Jacob P. Den Hartog Distinguished Educator Award which is "conferred for excellence in teaching mechanical engineering which has served as an inspiration for students and has fostered the development of physical insight and engineering judgment."

Professor John B. Heywood was elected a Fellow of the Society of Automotive Engineers for "exceptional professional distinction by reason of outstanding and extraordinary qualification, experience and sustained accomplishment in the field of automotive engineering."

Professor Roger D. Kamm received a Graduate Student Council Award for teaching.

Professor Bruce M. Kramer won the 1983 Society of Manufacturing Engineers' Outstanding Young Manufacturing Engineer Award "in recognition of significant achievement and leadership in manufacturing engineering."

Professor Robert W. Mann was elected president of the MIT Alumni Association, the second faculty member to be so honored. He was also selected as the 1983-84 recipient of the James R. Killian, Jr. Faculty Achievement Award, which recognizes extraordinary accomplishments by MIT faculty members and carries the title of Killian Award Lecturer.

Professor David M. Parks won a Best Paper Award from the Pressure Vessel and Piping Division of the ASME.

Professor Ernest Rabinowicz received the MIT-Technion-Israel Institute of Technology Jacob Kurtz Memorial Lectureship in Materials. He delivered a lecture on "The Importance of Tribology in Modern Society" at The Technion in April.

Professor Warren P. Seering was a co-recipient of the first Harold E. Edgerton Award, established in January in honor of Institute Professor Emeritus Edgerton. The award recognizes young faculty for outstanding achievement in research, scholarship and teaching.

Professor Ioannis V. Yannas received the 1982 Science Digest Award for the successful design and clinical evaluation of an artificial skin from Cutty Sark.

New Faculty and Staff

Two new faculty members joined the Department on July 1, 1982. Dr. Steven Dubowsky joined the Systems and Design Division as Professor with research activities in kinematics, mechanical dynamics and control; he is a member of the evolving Machine Dynamics Laboratory and has contributed to initiatives in robotics and intelligent machines for manufacturing. He is Associate Head of the Systems and Design Division and Associate Director of the Laboratory for Manufacturing and Productivity. Professor Dubowsky was a professor in the Mechanics and Structures Department at UCLA.

Dr. Anthony T. Patera was appointed Assistant Professor in the Thermal and Fluid Sciences Division. He received his SB and SM from this Department and his PhD in 1982 from the MIT Department of Mathematics. Professor Patera has been involved in heat transfer augmentation, crystal growth, transition to turbulence, turbulence modeling, and general computational fluid dynamics.

Dr. Yukikazu Iwasa was appointed Senior Research Engineer, strengthening the ties between the Department and the Magnet Laboratory.

Visiting Faculty

The Department had three visiting faculty, two of whom had been visitors during 1981-82. Dr. Richard E. Garrett, Director of CAD/CAM Research at Control Data Corporation spent a second year as Visiting Professor working with Professor David C. Gossard. Professor Helmut Kirchner of the University of Vienna, who was a Visiting Associate Professor in 1981-82, remained on as a Research Fellow to continue work with Professor Argon. Visiting Associate Professor A. George Thompson, Senior Lecturer in Mechanical Engineering at The University of Adelaide, South Australia, arrived in December to work on active suspension for passenger rail vehicles with Professor J. Karl Hedrick.

Other Visitors

We had 27 Visiting Scientists/Scholars/Engineers from 11 different countries: nine from the People's Republic of China, four from Japan, three from Korea, two from France, Spain and Italy, and one from Bulgaria, India, Israel, Yugoslavia, and Norway.

Resignations

The Department accepted with regret the resignations of Associate Professors Alician V. Quinlan and Peter W. Huber. Professor Quinlan resigned in January to become Associate Professor of Mechanical and Environmental Engineering at Duke University. She has maintained a contact with the Department through a lecturer appointment. Professor Huber has resigned to pursue a legal career and is serving in Washington as a clerk working for Justice Sandra Day O'Connor.

Retirement

Frederick H. Anderson, Technical Instructor in the Laboratory for Manufacturing and Productivity retired this year. He joined the Department in 1941 as an assistant and became a technical instructor in 1944 in what was then called the Machine Tools Laboratory. He earned the respect and admiration of all students with whom he came into contact over the years and will be missed.

DAVID N. WORMLEY

Department of Nuclear Engineering

The Nuclear Engineering Department serves the Institute through four major objectives: 1) by providing education, through teaching and research, to individuals from the U.S. and abroad interested in the peaceful uses of nuclear reactions, 2) by identifying and developing new scientific and engineering approaches to the practical application of nuclear phenomena, and translating these approaches to educational programs, 3) by contributing to a thorough understanding of nuclear energy and radiation in the national and international communities, and 4) by contributing to a thorough understanding of the issues which will determine the role of nuclear power in meeting domestic and world energy needs.

The Department's undergraduate and graduate teaching activities focus around the following disciplines: Fission Reactors, Controlled Fusion, Radiation Physics, including Biomedical Applications, and Energy Technology and Resources. Research is carried out by faculty and students as an integral part of our educational program. An important component of the educational strategy is the writing of textbooks and the communication of teaching and research results through professional publications and oral presentations. The demand for public service activities in the Nuclear Engineering Department involving questions of public policy with respect to the commercial application of fission energy and the direction of the fusion research program is strong. This demand is met by testimony on proposed legislation for the Government, short courses and consulting for industry, membership in committees of professional societies, and volunteer work for educational and other non-profit institutions. The following annual report for the period ending June 30, 1983, highlights our recent activities in each of these discipline areas in fulfilling the foregoing Department objectives.

ACADEMIC PROGRAM

During the academic year 1982-83, the Department graduate population remained within the 150 to 160 range. As of the fall term 1982, our undergraduate enrollment totaled 35 students. Eight freshmen, who elected nuclear engineering during the past year, will join the Department next September.

The Department's system of recruiting domestic graduate students continued to be successful. This year the number of domestic inquiries regarding admission was 283 and of these inquiries 43 domestic candidates have applied for September 1983 admission. 20 of these applicants were approved for financial aid and have accepted our offer of admission. Subsequently, several (4) have been awarded fellowships from outside funding groups such as the Department of Energy (DOE) and the National Science Foundation (NSF).

The Department awarded 15 doctorates, four nuclear engineers, and 30 master of science degrees during the academic year 1982-83 -- a total of 49 advanced degrees. Also, 12 bachelor of science degrees were awarded.

The Engineering Internship Program, which offers undergraduates the opportunity to have significant on-the-job experience as part of their overall education, has been successful since it was initiated in the summer of 1978. A total of 9 students -- three graduates, three seniors, and three juniors -- are now in the program. Companies which have placed students from our Department are Brookhaven National Laboratory, Commonwealth Edison, EG&G Idaho, Stone & Webster Engineering Corporation, and Los Alamos National Lab.

A new doctoral program in the area of radiological sciences has been established to supplant the medical radiological physics program of previous years. This program, under the direction of Professors Gordon Brownell and Alan Nelson, has been funded by the NIH. The objective of this program is to educate students in the varied applications of radiation in medicine and correspondingly to expand the research frontiers in this area. Academic and research objectives may be pursued in any one of four specialty areas: medical therapy, imaging and diagnostic technology, radiopharmaceutical chemistry, and radiation biophysics.

A new master's program was initiated in the area of health radiation physics. This program is being developed by Professor Otto Harling. It is designed to combine a strong engineering background with course work and thesis research in the principles of radiobiology, radiation dosimetry, radiation measurement and radiation risk exposure management. Significant experience in radiation management is provided at the MIT Reactor, the Bates Accelerator and at various facilities in Boston-area teaching hospitals. Existing courses in the Nuclear Engineering Department and the Harvard School of Public Health comprise the recommended course curriculum with one exception. A new laboratory course, Health Physics II, is being developed for this program. The first pilot student has begun her studies under a support grant from a nuclear utility.

Professor David Lanning was involved in a new undergraduate course entitled Human Factors in Design. This was a joint offering with the Departments of Mechanical Engineering (Professor Thomas Sheridan) and Psychology (Professor Alan Hein).

A special summer session program on Nuclear Power Reactor Safety, directed by Professors Norman Rasmussen and Neil Todreas, was offered once again during the summer of 1982. 176 attendees from 11 countries participated in this two-week program. During June 1983, Professor Carolyn Heising presented a course entitled Probabilistic Risk Assessment: Uses and Applications to Decision Making in the Nuclear Industry. 35 people attended this offering.

In cooperation with the Center for Advanced Engineering Study (CAES) Seminar Office, various faculty members coordinated and/or participated in several course offerings during the past year. Professor Heising helped coordinate and, along with Professor Rasmussen, participated in a program on Reliability Analysis and Risk Assessments, offered for the first time in the spring of 1983. This effort was complemented by a fall 1982 ILP seminar on the same subject, coordinated by Professors Heising and Ernst Frankel from the Department of Ocean Engineering. A three-day course on Advances in Nuclear System Thermal Analysis was offered during May 1983, under the direction of Professor Mujid Kazimi. Participants included outside lecturers as well as Professors Michael Golay, Rasmussen, Todreas, and Andrei Schor. It was very well received by the 35 attendees (including 15 from foreign countries). Also during May 1983, a six-day course on Light Water Reactor Design and Safety Analysis was presented. This effort, coordinated by Dr. L.S. Tong, former director of safety research at the U.S. Nuclear Regulatory Commission, was attended by 22 people from 10 countries. NED faculty who participated in the program included Professors Ronald Ballinger and Michael Driscoll.

STUDENT ACTIVITIES

The MIT chapter of the American Nuclear Society (ANS) has completed another productive year. Activities have included departmental seminars, student/faculty meetings, departmental steak fries, course evaluations, and numerous engagements speaking to Boston-area groups concerning nuclear power issues.

Honors and Awards

The student chapter of the ANS was named a recipient of the 1983 Glasstone Award. This national award was presented to the members of the student branch for accomplishing notable achievements in public service and the advancement of nuclear engineering during the year.

At the ANS 29th annual meeting held in June 1983, the Verne R. Dapp Memorial Scholarship Award for excellence to a full-time graduate student in the field of nuclear engineering and science was presented to Carl Malbrain. At the same meeting, Tue Nguyen, an undergraduate, was named recipient of the John LaMarsh Scholarship Award for outstanding efforts and academic achievements.

The best student paper award for the Material Science and Technical Division was presented to Michael Manahan at the 1982 ANS Winter Meeting. One of Professor Allan Henry's students, Hussein Khalil, received the best paper award from the Reactor Physics Division for his presentation at the ANS Topical Meeting on Advances in Reactor Physics and Core Thermal Hydraulics, held at Kiamesha Lake, NY, in September 1982.

Eight graduate students were inducted into Alpha Nu Sigma, the national honor society for nuclear science and engineering. In addition, Professor Manson Benedict was elected as the first honorary member of the local section.

During the past academic year, national fellowships were presented to several of our graduate students. Thomas Downar received a fellowship from the Hertz Foundation. The Department of Energy (DOE) awarded Magnetic Fusion Energy Fellowships to James Doyle and Deborah Hanchar. Recipients of a DOE Nuclear Science and Engineering Fellowship were Derek Ebeling-Koning, Richard Burke, and Vincent Manno. An incoming graduate student, Anthony D'Amico, will also be receiving a DOE NSE fellowship beginning in September 1983.

Other Student Awards

During the academic year, approximately 70 percent of our graduate student body was appointed to the graduate student staff, receiving financial aid in the form of research and teaching assistantships. Included in this percentage were Andrei Schor and Peter Roemer, who received the graduate Instructor G appointment. The Department was pleased to award the Theos J. Thompson Memorial Fellowship to Michael Kotlarchyk. The Sherman Knapp Scholarship, funded by Northeast Utilities, was awarded to Joy Maneke. Jon Anderson was selected to receive the first Schlumberger Fellowship in Radiation Physics. The first Graduate Fellowship in Health Physics, which was funded by the Consumers Power Co., was presented to Susan Reilly. Other students receiving financial awards included Robert Witt, a Rockwell International

Graduate Fellowship recipient, Warren Krueger, a fellowship from NASA, and Ray Gamino, a GEM Award. The Department was awarded two MIT-endowed tuition scholarships. Students selected for one term of support were Stephen Allen, Robert Heft, Carl Malbrain, and Cynthia Nitta.

Three undergraduate students, Geoffrey Gordon, Jay Elson, and Akiko Kodaka, were chosen to receive fellowships from funds provided by the Institute of Nuclear Power Operations (INPO) member utilities. A Uniroyal Undergraduate Research Grant for the spring term was awarded to Dinh Le.

RESEARCH

The Department conducts research in the areas of 1) fission reactors (reactor engineering, reactor physics and fuel management, nuclear materials, and reliability and risk analysis), 2) controlled fusion (applied plasma physics and fusion reactor technology), 3) radiation physics, including biomedical applications (condensed matter sciences and biomedical and radiological sciences), and 4) energy technology and resources. During the fiscal year ending June 30, 1982, Department faculty supervised a research volume of $2,722,302, including research funded through the Department, the Department of Materials Science and Engineering, the MIT Energy Laboratory, the Harvard-MIT Division of Health Sciences and Technology, the Nuclear Reactor Laboratory, the Plasma Fusion Center, and the Research Laboratory of Electronics.

Continuing Research Projects

Professors Lanning and John Meyer, working closely with Professor Sheridan and the Charles Stark Draper Laboratory staff, are continuing their research on the problems of the man-machine interface in a nuclear power plant control room. In the area of reliability analysis, Professor Rasmussen is continuing study on the economic consequences of nuclear accidents and the reliability of standby safety systems. Professors Kazimi, Meyer, and Heising continued their research in the area of PWR severe accident analysis under the sponsorship of the Electric Power Research Institute (EPRI) and Fauske & Associates (FAI). Under the supervision of Professor Heising, progress has been made in the areas of common cause and human reliability analysis. Professor Elias Gyftopoulos' work on the foundations of quantum thermodynamics, including an equation of motion for quantum physics and the distinction between quantal and nonquantal uncertainties, continues. He is also working on cost-effective methods for energy conservation, as well as Markovian reliability analyses of large power systems.

In the area of reactor physics, Professor Henry has continued his work on numerical modeling of the behavior of light-water moderated reactors. Professor Driscoll and his students continued research on improved LWR fuel management methods. He is also continuing to supervise research on the recovery of uranium from seawater.

In the area of nuclear materials, Departmental research continues to be active. Professor Harling is continuing two major programs in this area. One of these uses the MIT Research Reactor to investigate the influence of plasma bombardment on the mechanical performance of fusion reactor first walls. The second effort concerns development of improved nuclear structural alloys for the critical fusion reactor first-wall application. Professor Kenneth Russell's theoretical and experimental studies on defect aggregation in irradiated alloys continues, with emphasis on fusion reactor first-wall applications. Professor I-Wei Chen continues his research on embrittlement problems in ferritic stainless steels due to intense irradiation for both fusion and fission applications. He is also involved in researching non-metallic nuclear materials for fusion insulator and radioactive waste forms. During the past year, both he and Dr. Frederick Best completed modelling the mechanisms by which a zirconium metal fire might develop and spread in a drained spent fuel storage pool. Examinations of an external stress field and magnetic field on irradiation performance were actively pursued. An experimental program on zirconia transformation was established. Also, effects of solute segregation under irradiation were studied.

The Department continues its broad activities in the area of thermal hydraulics and fluid flow. Professors Kazimi, Lanning, Schor, Todreas, Golay and Meyer have contributed individually and jointly to studies of natural convection and sodium boiling behavior in Liquid Metal Fast Breeder Reactors (LMFBR), PWR steam generator modeling, single and two-phase flow in light water reactors, cooling tower fluid flow, flow-induced vibration of steam generator tubes, and thermal problems in fusion devices. This last effort on divertor design of TOKAMAK fusion machines is an excellent example of how the broad engineering design of fission technology has many direct applications to the engineering design of fusion machines.

Professor Lawrence Lidsky, along with members of the Plasma Fusion Center, is continuing research in the area of reactor design studies. He also directs an experimental study of electromagnetic forces in fusion reactor structures, as part of Professor Kazimi's fusion reactor hazard evaluation study. Another of his efforts involves the rapidly evolving area of stellarator/torsatron physics. This work is part of a joint project with Professor Jeffrey Freidberg. Professor Freidberg has been working in the area of plasma stability using magnetohydrodynamic (MHD) theory. In particular, he is involved in researching stellarators and tandem mirrors. Research on nonlinear ordered and stochastic systems with various applications to laboratory and astrophysical plasma turbulence has been continued by Professor Thomas Dupree.

Professor Meyer has continued first wall/blanket engineering analysis for tokamak fusion system studies. Professor Kazimi continued his studies of fusion reactor safety, with major emphasis on the development of a methodology for assessment of reactor design impact on safety.

Professors Sow-Hsin Chen and Sidney Yip lead the Department's efforts in the area of applied radiation physics. Professor Yip is now primarily interested in computer simulation studies of materials behavior and properties. In the area of nuclear medicine, Professor Brownell continues his interest in the development of neutron capture therapy for the treatment of glioblastoma and other diseases. This work is in conjunction with the Nuclear Reactor Laboratory. At the Massachusetts General Hospital, he continues his activity in the development of positron tomography and its application in medical diagnosis and patient care. In the area of radiation biophysics, Professor Nelson is continuing several research efforts. The effects of ionizing photons and particles on embryos are being investigated in collaboration with the Lawrence Berkeley Laboratory. In conjunction with the Harvard Medical School, he is studying the effects of ionizing radiation on vasculature. This project is directed toward improved methods of tumor treatment. Professor Nelson is also continuing various investigations in microstructure of organisms and materials, and in laboratory automation and digital image analysis. He is Director of the Whitaker Laboratory of Microscopy, where these projects are being carried out.

Professor Richard Lester is continuing his work in the area of radioactive waste management and disposal; during the past year his research has been directed toward the thermal design and economic evaluation of geologic repositories for high-level radioactive waste.

Professor David Rose and Dr. Marvin Miller, together with Dr. Christopher Hill of the Center for Policy Alternatives and Professor Carson Agnew of Stanford University, continued a study of the technological and social options and consequences related to carbon dioxide buildup in the atmosphere. In this work, they have collaborated closely with the Institute for Energy Analysis in the development and use of a global energy model that relates resources, prices and demand including regional and inter-regional costs, possibility of technological improvement, etc. This work is supported by the National Science Foundation (NSF).

New Research Projects

Depàrtment faculty have initiated several new projects during the past year. Professor Lester has launched a major new research project in the area of nuclear power plant design innovation. Other faculty members participating in this project include Professors Driscoll, Golay, Lanning, Lidsky, Rasmussen, and Todreas. The general objective of the project is to explore the role of nuclear power plant design innovations in increasing the attractiveness of the nuclear option to US electric utilities in the 1990's. A range of design options is being studied. The research was initiated with financial support from the School of Engineering. During the forthcoming year, the project will be funded by a grant from the National Science Foundation.

New research in the area of thermal hydraulics of natural convection and recirculation of fast breeder fuel assemblies has been set up by Professor Todreas. Professor Golay is currently involved in researching nuclear accident off-site radioactive release reductions. Professor Schor initiated a project to investigate the application of finite element methods in two-phase flow numerical modeling. In conjunction with colleagues from the Materials Science and Engineering Department, Professor Harling has established a program to obtain the first base line irradiation effects data for copper alloys at significant neutron doses and at relevant service temperatures.

Professor Ballinger's research activities have been concentrated in two major areas: environmentally assisted fatigue and stress corrosion cracking in nickel base alloys, and Light Water Reactor (LWR) fuel performance. He has established an experimental laboratory for the study of fatigue in high temperature aqueous environments that is unique to a University and represents the state of the art in the field. He has also been involved in the development of advanced technologies for predicting LWR fuel performance using deterministic as well as probabilistic techniques. The resulting methodology represents a significant advance in the field.

Professor Nelson has initiated research in non-genetic radiation damage in individual living cells and is developing new technologies in the area of microscopic image science. Professor S.H. Chen has developed a new technique for using small angle neutron scattering to study the structure and interparticle correlations in strongly interacting colloidal solutions. He and his students have produced new results on the structure of ionic micelles and microemulsions which are of great interest to the oil industry.

FACULTY

Andrei Schor was appointed as an assistant professor of nuclear engineering. His activities will be in the area of numerical methods in reactor analysis.

Ian Hutchinson will be joining the Department in September 1983 as an associate professor of nuclear engineering. He will specialize in the experimental plasma physics area.

The Department is pleased to announce that Professor Kim Molvig was promoted to associate professor with tenure.

The Department was happy to welcome the following visiting faculty during the 1982-83 academic year: Gilbert B. Melese-d'Hospital was appointed visiting professor during the spring of 1983 to teach 22.312, Engineering of Nuclear Reactors. He visited us after retiring from General Atomic Company. Johan Peter Goedbloed was appointed visiting associate professor for the period 8/1/82 - 8/1/83. Dr. Goedbloed shared the teaching responsibilities for 22.615/616, MHD Theory of Magnetic Fusion Systems I & II, and participated in the study of MHD equilibrium in torsatrons and stellarators research funded by the US Department of Energy. Dr. Goedbloed is from the Fom-Instituut Voor Plasmafysica. Dietmar Konrad Winje was appointed visiting associate professor for two years effective June 1, 1982. He is on leave from the Technical University of Berlin. Among his tasks at MIT will be the development of educational modules for industrial energy conservation as well as co-teaching 22.84, Nuclear Energy Policy Analysis, with Professor Lester during the fall 1983.

Professor Kazimi enjoyed a sabbatical leave during the past academic year. During this period he worked on definition of the environmental impact of fusion energy relative to other energy sources and on development of a textbook for thermal analysis of nuclear reactors.

Professor Rose spent the spring semester at the Resource Systems Institute of the East-West Center in Honolulu.

Professor Rasmussen was appointed by President Reagan to the National Science Board for a six year term. He continues to serve as Chairman of the MIT Committee on Reactor Safeguard, as well as chairman of the MIT School of Engineering Committee on Energy Systems. At the EG&G Idaho National Engineering Laboratory, he is chairman of the Scientific Review Committee, and chairman of the Fusion Safety Committee.

Professor Lester continues to serve as chairman of the MIT School of Engineering Committee on Energy Education. Professor Golay continues his involvement in the nuclear technology portion of the Energy Lab's Electric Utility Program. The interdepartmental Nuclear Reactor Laboratory continues under the directorship of Professor Harling.

Department faculty who continue to serve in an administrative capacity within the Department include Professor Driscoll in the recruiting area and Professor Yip as financial aid officer. Professor Henry continues to represent the Department on the CGSP. Department admissions is handled by Professor Lanning, who also serves as UROP coordinator for the Department.

Professor Lanning continues as a member of the MIT Committee on Reactor Safeguard, the Safety Audit Committee at Northern States Power Co., the Nuclear Safety Review and Audit Committee at Boston Edison, and the Source Term Review Group for Stone and Webster Engineering Corporation. Professor Kazimi serves as chairman of the Nuclear Heat Transfer Committee of the American Institute of Chemical Engineering. He is also on the Advisory Committee of the DOE Fellowship for Magnetic Fusion Energy Technology. Professor Freidberg continues on the Executive Committee of the Stellarator Advisory Panel for the DOE. Professor Meyer continues to serve on the Review Committee for the Applied Physics Division at Argonne National Laboratory. Professor Heising served as a board member of the Northeast Section of the ANS. She continues to serve on the national program committee of the ANS Reactor Safety Division, the NEED committee, and the Honors and Awards Committee. She acted as technical program cochairperson for the 1983 ANS Topical Meeting on Degraded Core Analysis.

Professor S.H. Chen has been elected as chairman of the Gordon Conference on Physics and Chemistry of Water and will be organizing a conference in the summer of 1984. He was an invited speaker at the American Chemical Society's March meeting in Seattle; and at the 57th Symposium on Colloid and Interface Science, held in Toronto during June.

Professor Driscoll was selected by the NSF as one of the US delegates to the US-Japan Joint Seminar on the Thorium Fuel Cycle, held in Nara, Japan, in October 1982. He has also been appointed the US representative to the upcoming IAEA-sponsored conference on the recovery of uranium from seawater.

Professor Rose serves on the Advisory Committee of the Congressional Office of Technology Assessment, dealing with the future of conventional nuclear power. Professor Todreas continues to serve on the Executive Committee of the ANS. He is also serving on the DOE sponsored panel evaluating the National Light Water Reactor Research and Development Programs. He continues on the editorial board of the thermal design section of the Journal of Nuclear Engineering and Design. Professor Henry is a member of the editorial review board for Nuclear Science and Engineering.

Honors and Awards

Several of the Department faculty were recognized with honors during the past year. Professor Rasmussen was appointed McAfee Professor of Engineering. He also received the Distinguished Alumni Award from Gettysburg College. Professor Todreas was elected as a Fellow of the American Society of Mechanical Engineers. Professor Rose was named to the National Academy of Engineering's Energy Engineering Board. Professor Nelson was awarded the first Keck Professorship in Biomedical Engineering, an endowed chair sponsored by the William M. Keck Foundation for career development. The student chapter of the ANS presented its annual outstanding teacher award to Professor Lester.

SUMMATION

The fiscal year 1983 saw the submission of our five-year long-range plan to the School of Engineering and the commencing of two of our four major new tasks: Biomedical & Radiological Sciences and the Nuclear Power Plant Reactor Innovation Study. Both of these programs have been described previously in this report.

In addition, we had a very successful Visiting Committee meeting in December, 1982. Now we look forward to our 25th Anniversary to be celebrated this fall, 1983, honoring our esteemed colleague, Dr. Manson Benedict, for whom a fellowship is now being established.

NEIL E. TODREAS

Department of Ocean Engineering

In the fall of 1982, the Department of Ocean Engineering completed a five-year plan that set forth the objectives of the Department, described the strategies for achieving those objectives, evaluated present programs, and proposed new initiatives. The objectives are three-fold:

(1) to educate people for careers (a) in the practice, teaching, and development of ocean engineering and (b) in the organization and management of ocean engineering systems;

(2) to extend our knowledge (a) of ocean engineering principles and technology and (b) of the social, economic, political, and legal aspects of ocean engineering;

(3) to provide services to government, industry, and society that are relevant to the foregoing goals and for which the Department's special expertise makes it an appropriate source of knowledge and counsel.

Since ocean engineering is a young field, we considered it important to define its scope. For the purpose of our program at MIT, ocean engineering is defined as those areas of science and technology that relate to engineering development and operations in a marine environment. It includes

(a) design, construction, and operation of
  (i) vehicles for marine transportation,
  (ii) structures and equipment for recovering resources from the ocean,
  (iii) work systems for exploring the ocean and its resources;

(b) organization, management, and operation of
  (i) transportation systems having marine components and interfaces,
  (ii) systems for exploiting marine resources,
  (iii) systems needed by the government in the marine environment;

(c) systematic acquisition and development of new knowledge contributing to the more effective design and operation of ocean engineering systems and their components.

Major progress has been made during the year in restructuring our courses of instruction so that we can better meet our objectives; the major changes are described below. In research, some of our areas are flourishing, while others are suffering from the effects of the worldwide oil glut and the present administration's cutback on nonmilitary research spending. Some highlights of our recent research will be briefly described.

PROGRAMS OF INSTRUCTION

Undergraduate Program

A curriculum Committee was organized, chaired by Professor J. Nicholas Newman, with one responsibility being to produce a plan for the Department's undergraduate programs in ocean engineering and in naval architecture and marine engineering. The Committee considered three possible directions: (i) abolish the SB programs, (ii) establish a five-year program jointly with the Department of Mechanical Engineering, leading to the SB in mechanical engineering and the SM in ocean engineering, and (iii) strengthen the Department's SB programs so that they can stand alone. The plan that will actually be followed is a combination of the second and the third. The Department will discontinue its sophomore-level subjects in fundamental engineering science and, instead, take advantage of existing comparable subjects in other departments; in addition, we expect to participate in the teaching of those subjects, especially in the Department of Mechanical Engineering. A new second-year subject will be introduced that emphasizes the use of the computer in design. Two existing graduate-level subjects will become undergraduate subjects, a change that will increase the depth of the Department's undergraduate programs. Plans for collaborating with the Department of Mechanical Engineering are still being worked out.

Ocean Systems Management Program (Course XIII-B)

In September 1982, Assistant Professor Harilaos N. Psaraftis was named Head of Course XIII-B. During the year, the Ocean Systems Management (OSM) Program underwent a major reorganization. The goals of this effort were to better define the goals of the Course, improve the methods of reaching those goals, and strengthen the links of the Course with the rest of the Department of Ocean Engineering and with other related units within MIT. After nine months of intensive effort, involving almost weekly meetings of the

XIII-B Committee and the Department Head, plus discussions with faculty inside and outside of the Department and with students, the following were accomplished:

(a) The field of ocean systems management was explicitly defined in terms of the integration of theory, methodology, and experience from six fundamental disciplines (engineering, economics, operations research, business administration, public policy analysis, and law) to solve problems in the organization, management and operation of ocean engineering systems. This definition constitutes a departure from the previous view of the field, which was based only on the areas of application (the main ones being ocean transportation and the development of natural resources). The integration of the six disciplines was adapted as the major feature of the program and the major factor differentiating the Course from related programs within MIT (Sloan School, Center for Transportation Studies, Technology and Policy Program, etc.)

(b) To promote the creation of new knowledge in the area, a completely new PhD program was proposed and approved by the ocean engineering faculty for students wishing to pursue doctoral studies in OSM-related areas. Previously, such students had no available avenues within the Department of Ocean Engineering. (During the past five years, about one-fourth of all doctoral theses of ocean engineering students were written in OSM-related areas, but these degrees all carried other designations, derived from the procedural routes followed by the candidates.) The new OSM examination system complements the existing ocean engineering system and will be administered in close coordination with it.

(c) The XIII-B SM program was revised. A more solid core of subjects was adopted, including a proposed new subject that would explicitly integrate the six OSM disciplines. Development of the new subjects will take place during 1983-84, and the new program will be implemented the following year.

(d) The OSM faculty has a new sense of unity, with clearly stated goals. Its communication with the rest of the ocean engineering faculty, especially with those most concerned with design, has been enhanced. And its relationships with other units in MIT are being further developed.

Naval Construction and Engineering (Course XIII-A)

This course was started over 80 years ago to provide graduate education to mid-career US naval officers who will subsequently assume responsibility for the development of naval ship systems. During the past year, there were over 50 officers enrolled in this program. Two active-duty USN officers serve as faculty members in the Department (Professor David V. Burke and Associate Professor Terrence L. Tinkel).

In the long history of this Course, which was developed by MIT specifically to meet the needs of the US Navy, there has never been a contract or other formal agreement between the two organizations. The changing needs of the Navy have been accommodated informally and, for the most part, successfully. But events in the past year may now force modification of this relationship. Course XIII-A has long been a three-year program, quite possibly the most highly structured graduate program in MIT. The USN officers who entered the Course in 1982, however, were assigned to MIT for only two years. This unilateral action by the Navy could undermine the cooperative basis on which this program has been developed since 1901. Course XIII-A is an MIT program, not a Navy program, but this fact has been overlooked, perhaps because of the informal nature of the MIT/Navy relationship. We are still trying to resolve this problem within our traditional relationship, and we are encouraged that the Naval Sea Systems Command strongly supports the continuation of the full three-year program.

Our relationship with the Naval Sea Systems Command has been strengthened by the establishment of a NAVSEA professorship in the Department with year-by-year funding from the Navy. A memorandum of understanding was signed in November 1982, indicating the Navy's intent to support this program for at least five years, and funding for the first year was received in May 1983.

Joint MIT/WHOI Program in Oceanographic Engineering (Course XIII-W)

Students entering the Joint Program must satisfy all admission and performance requirements of their departments in both MIT and WHOI. For most Joint Program students in the Department of Ocean Engineering, the counterpart is the WHOI Department of Ocean Engineering. The double admission requirement has worked well, but students have expressed some concern that our PhD qualifying examinations are too narrowly focused. In cooperation with the WHOI faculty, we are considering a modification to our doctoral examinations to alleviate this problem. A major purpose of the Joint Program is to provide the broadened opportunities that are only possible with the complementary capabilities of the two institutions. We are committed to the vigorous development of the Joint Program.

RESEARCH

One of the great frontiers of ocean engineering is the Arctic. The exploitation of energy resources and the problems of military operations in the Arctic have combined to stimulate unprecedented interest in

this hostile but fragile environment. Large-scale engineering operations are already being undertaken in the Arctic, although there is little experience or knowledge on which to base sound engineering decisions. The Department of Ocean Engineering is involved in two areas of Arctic science and technology.

Professors Ira Dyer and Arthur B. Baggeroer are chief scientists of the Arctic Acoustics Projects sponsored by the Office of Naval Research. It is a large multifaceted program in the eastern Arctic Ocean emphasizing long-range, low-frequency acoustics and geophysics. It incorporates measurements that are required both for the successful operation of sonar and underwater communication systems and for improving our understanding of the geophysical structure of the eastern Arctic. This year, Professors Dyer and Baggeroer are also collaborating in the Marginal Ice Zone Experiment, a project involving scientists and engineers from eight nations. Professor J. Kim Vandiver and several graduate students have joined them in an expedition into the marginal ice zone on a West German research icebreaker.

Assistant Professor Paul Xirouchakis, under sponsorship of the Sea Grant Program, has been developing methods for the rational selection of criteria for strengthening of ships for operations in ice. At present, there is little guidance available for determining ice loads on ships or for designing extra strength into ships to withstand such loads. Ice itself is a structure with largely unknown properties; its failure modes must be known and understood in order to predict the loads that it can impose on a ship or other structure. Various kinds of ship structures must also be considered, along with their possible collapse mechanisms. Professor Xirouchakis's research spans the range of problems from fundamental ice mechanics to the development of rules for ice strengthening of ships.

Professor Koichi Masubuchi has several projects underway that are at the forefront of structure fabrication technology. The Sea Grant Program supports his project for the development of a system capable of performing simple underwater welding and cutting operations by remote manipulation techniques. The purpose is two-fold: (i) to permit such operations to be accomplished under hazardous conditions and (ii) to reduce the need for skilled welder-divers. Eventually, such techniques may be used in conjunction with unmanned submersibles in deep water. Professor Masubuchi is also carrying out a feasibility study for NASA to evaluate novel joining techniques that may be used in space applications. The objective of this project is to initiate a research program for the development of packaged, remotely controlled welding systems for construction and repair of structures in space. Recently, Professor Masubuchi has started a long-range program on the use of high-power lasers for welding, cutting, heat treating, and metal forming. An integral part of this research is the development of sensing and control systems to eliminate or reduce dependence on the skills of individual operators.

Professor Jerome Milgram and Assistant Professor Michael Triantafyllou are being supported by the Office of Naval Research to develop a theory for the forces and motions encountered during towing operations in random seas. This work is motiviated by a history of tows that are disrupted by failure of the towing line, caused by excessive sea-induced motions of the towing ship and the towed object. The theoretical predictions will be checked against experimental data obtained in Navy tests, in which Professors Milgram and Triantafyllou expect to participate. The product of the research will include practical guidelines for the personnel who conduct towing operations for the Navy.

FACULTY

Professor Chryssostomos Chryssostomidis was promoted from Associate Professor to Professor of Ocean Engineering effective July 1, 1982 (retroactive). He was appointed Director of the MIT Sea Grant College Program July 1, 1982.

Professor Harilaos N. Psaraftis was promoted from Assistant Professor to Associate Professor of Marine Systems effective July 1, 1983.

Professor Michael S. Triantafyllou was promoted from Assistant Professor to Associate Professor of Ocean Engineering effective July 1, 1983.

Professor Paul Xirouchakis was promoted from Assistant Professor to Associate Professor of Ocean Engineering effective July 1, 1983.

Commander Terrence L. Tinkel, USN, joined the faculty as Associate Professor of Ocean Engineering on August 15, 1982.

Professor Dick K. Yue joined the faculty as Assistant Professor of Ocean Engineering on January 1, 1983.

Professor Patrick Leehey transferred his home department to the Department of Mechanical Engineering effective July 1, 1982. He will continue his association with this Department as Professor of Mechanical and Ocean Engineering.

Professor Ernst Frankel was on partial leave during the Spring Term, serving as an advisor on ports and shipping to the World Bank at the headquarters in Washington.

Professor Joao G. de Oliveira, Associate Professor of Ocean Engineering, resigned from the Department to join the Production Engineering Services Division of Conoco, Inc., in Houston, Texas.

VISITING FACULTY AND STAFF

Professor Tomasz Wierzbicki of the Institute of Mechanics, Polish Academy of Sciences, taught subjects in ocean structures and studied dynamic plasticity (including crashworthiness) and ice mechanics, which will be crucial to the solution of many ocean engineering problems in the next decade. Dr. Wierzbicki is a leader in the development of design concepts and methods for minimization of impact damage to ships and offshore structures.

Dr. Martin Greenhow visited the Department as a post-doctoral associate, collaborating with Professor J. Nicholas Newman on an ONR-sponsored project on the interaction of floating bodies with waves.

Professor Jean P. Ioannidis from the National Technical University of Athens was a visiting professor, studying the practical aspects of ship power and propulsion with Professor A. Douglas Carmichael.

Professor Wataru Koterayama of Kyushu University, Japan, was a visiting research engineer, conducting research with Professor M. Triantafyllou on viscous flow fields around cylinders in waves.

Dr. Si Kwon Young was a visiting research engineer, studying the effects of ship operating characteristics on ship performance and developing dynamic ship-operation cost models with Professor Ernst G. Frankel.

ACTIVITIES AND AWARDS

Professor Martin Abkowitz was MIT representative to the American Towing Tank Conference (1982) and was elected a member of the Seakeeping Committee. Professor Abkowitz was also a member of the Society of Naval Architects and Marine Engineers (SNAME) Scholarship Committee.

Professor Ira Dyer received the 1982 IEEE Council on Oceanic Engineering Distinguished Technical Contribution Award. This award is given annually for outstanding technical contribution to electrical engineering in the ocean having a demonstrable influence on the course of oceanic engineering.

Professor Judith T. Kildow was appointed a member of the Board on Ocean Science and Policy of the National Research Council.

Professor Henry S. Marcus was elected a Member of Council by SNAME. Professor Marcus was also chosen to present the Sixth Donald McKernan Lecture at the University of Washington.

Professor T. Francis Ogilvie was appointed to the Executive Committee of SNAME at the Society's annual meeting in November 1982.

Professor Michael S. Triantafyllou was selected Doherty Assistant Professor in Ocean Utilization.

Professor J. Kim Vandiver was awarded the ASME Arthur Lubinski Award for best petroleum mechanical engineering paper at the 1983 Offshore Technology Conference. The paper was entitled "Drag Coefficients of Long Flexible Cylinders."

CONFERENCES

During the past year, the Department of Ocean Engineering joined in the sponsorship of two highly successful technical conferences:

Conference on Behaviour of Offshore Structures (BOSS '82) is a triennial conference sponsored by MIT, Norwegian Technical University (Trondheim), University College London, and Delft Technological University. In August, the third BOSS Conference was held at MIT, with Professors Chryssostomidis and Jerome Connor (Department of Civil Engineering) as co-organizers. Several hundred researchers and engineers assembled from all parts of the world for four days of technical papers and displays.

Arctic Technology and Policy Conference was held in March 1983, under the joint sponsorship of the Department of Ocean Engineering and the MIT Sea Grant College Program. Professors Chryssostomidis and Dyer were the co-organizers. The Conference brought together industry and government leaders concerned with technology, regulation, and national defense in the Arctic.

HART NAUTICAL MUSEUM AND COLLECTIONS

The Hart Nautical Museum has now operated for a second year under the direction of Mr. Warren Seamans, Director of the MIT Museums and Historical Collections. The Department has proposed that this arrangement be made permanent, in view of the many improvements in the collections and their environment that have been made during this period. Mr. John Waterhouse has continued to serve as Acting Curator, and he has agreed to stay on at MIT in the coming year as Curator. Mr. Waterhouse has begun the tremendous task of cataloging the many thousands of documents, plans, and pictures in the Collections.

During the year, several special exhibits were organized:

(i) "William A. Baker '34 - A Tribute" opened in February in the galleries in Building 5. Mr. Baker was Curator from 1964 to 1981. He was an authority on ships of the 17th and 18th centuries, and he was larqely responsible for the engineering in the modern reconstruction of the Mayflower. Mr. Baker died in 1981, just a few months after retiring.

(ii) "The Wizard of Bristol, Nathanael Herreshoff" opened in April in the Margaret Hutchinson Compton Gallery of Building 10. Mr. Herreshoff was an alumnus of MIT, Class of 1870. The exhibit shows his accomplishments as a naval architect and marine engineer. It features original drawings, fittings, and machinery.

(iii) A show on the yacht designs of Professor George Owen has been installed at the MIT Museum in Building N52. It includes photographs of vessels and some of his original drawings.

ROBERT BRUCE WALLACE PRIZE AND LECTURE PROGRAM

The fourth Robert Bruce Wallace Academic Prize, for the 1983-84 academic year, will be awarded to William Coney, Class of 1984. This Prize was endowed by Albert H. and Marion W. Chatfield in memory of Mrs. Chatfield's father, Robert Bruce Wallace, Class of 1898, an alumnus of the Department and former President of the American Shipbuilding Company. The Prize is awarded to a student for demonstration of outstanding potential for success in ocean engineering, without regard to the student's financial need. The amount of the award covers tuition and modest living expenses for one academic year.

The Robert Bruce Wallace Lecture Program is also made possible through the generosity of Mr. and Mrs. Chatfield. The purpose of the Program is to bring advanced ideas in ocean engineering to the attention of students and faculty of the Department, the MIT community, and the public. The third annual lecture was presented on 2 March 1983 in conjunction with the annual Sea Grant Program Lecture. The lecture was given by Professor Ira Dyer of this Department and was entitled "Scientific and Technological Challenges of the Arctic." Professor Dyer is well known for his research in underwater acoustics and has most recently been studying the acoustic properties of the Arctic Ocean.

T. FRANCIS OGILVIE

Artificial Intelligence Laboratory

The primary goal of the Artificial Intelligence Laboratory is to understand how computers can be made to exhibit intelligence. Two corollary goals are to make computers more useful and to understand certain aspects of human intelligence. Current research includes work on computer robotics and vision, expert systems, learning and common-sense reasoning, natural language understanding, and computer architecture.

Professor Patrick H. Winston works on the problem of learning from precedents. Professor Robert C. Berwick studies learning in the context of natural language syntax acquisition. Professor Marvin Minsky works on general theories of intelligence and knowledge representation. Dr. J. Michael Brady, Professor Berthold K. P. Horn, Professor Tomaso Poggio, and Professor Shimon Ullman head efforts in computer vision. Professor John M. Hollerbach, Professor Tomás Lozano-Pérez, and their staff work on other aspects of Robotics. Dr. Thomas F. Knight and Professor Gerald J. Sussman work on the problems of integrated circuit design. Professor Randall Davis and Dr. Howard E. Shrobe work on expert systems that use functional and physical models. Dr. Charles Rich and Dr. Richard C. Waters explore the creation of intelligent programming environments. Mr. William D. Hillis and Dr. Knight explore the development of the Connection-Memory Machine, a special-purpose machine for concurrently manipulating knowledge stored in semantic nets. Professor Carl E. Hewitt studies distributed problem-solving and parallel computation.

The Laboratory's 140 members include 12 faculty members, 5 academic staff, 50 research and support staff, and 60 graduate students active in research activities funded by the Defense Advanced Research Projects Agency, System Development Foundation, Office of Naval Research, Air Force Office of Sponsored Research, National Science Foundation, Atari, Digital Equipment Corporation, International Business Machines, and Martin Marietta.

ROBOTICS

Professor Lozano-Pérez and Mr. Bruce R. Donald have been extending previous work on collision avoidance towards motion planning for multiple robots. Mr. Donald has developed a technique for characterizing the connectivity of a workspace to identify the classes of paths it contains. The path-planning system works by hypothesizing a *channel* containing a suggested path through free space. Inside the channel the constraints on motion are simpler than in the original workspace, and only one class of paths need be considered.

Professor Lozano-Pérez and Dr. W. Eric L. Grimson have been developing a tactile recognition system. Using polyhedral models of known objects, and given three-dimensional information about the position and surface orientation of the points of contact of a set of tactile sensors with an object, the system determines which of a set of known objects is being grasped and what the object's orientation must be relative to the hand.

Professor Hollerbach continued development of efficient algorithms for kinematics, dynamics, and trajectory planning. He developed a formalism for combining kinematics and dynamics that permit analytic solution for planning trajectories under actuator constraints. With Mr. Gideon Sahar, Professor Hollerbach developed an efficient algorithm for inverse kinematic accelerations through a process of wrist partitioning, which was also shown to simplify the dynamics. With Mr. Ki Suh, he developed a real-time implementation of full inverse kinematics, inverse dynamics, and resolved acceleration feedback control for a six-degree-of-freedom manipulator.

Professor Haruhiko Asada and Professor Hollerbach continued to develop an innovative direct-drive manipulator that uses no gears, which makes it very fast and accurate. Special high-torque, brushless motors have been developed for the manipulator. Recent experiments confirm that the manipulator has no backlash, small friction, and high mechanical stiffness. Currently, Professor Hollerbach is testing his manipulator control algorithms on this manipulator.

Dr. J. Kenneth Salisbury's research is concerned with the design and control of articulated hands. By better understanding the basic mechanics of manipulation with multiple-degree-of-freedom end effectors, the work is aimed at increasing the dexterity and adaptability of robots. Dr. Salisbury is implementing several experimental control systems for coordinating the tendons and fingers. The immediate goal is to test the utility

of coordinated stiffness control of grasped objects as outlined in Dr. Salisbury's previous work. It is expected that a high-performance servo system will be developed to enable rapid motions as well as delicate force control of the the fingers.

Professor Warren Seering and his students are investigating novel actuation methods with the goal of producing very fast and inexpensive actuators for manipulators.

In the vision part of Robotics, Professor Horn and his staff study the problems associated with representing the surfaces of objects in a way suitable for recognition from visual information. The extended Gaussian image provides a compact map of the surface normals of patches on the object that can be used to determine the attitude of an object in space.

The surface normal information is obtained from multiple images obtained using different lighting conditions. This method is called photometric stereo and depends on solutions of the image irradiance equation given multiple constraints. In practice, the solution is encoded in a lookup table. Dr. Katsushi Ikeuchi has worked with Professor Horn in combining photometric stereo with extended Gaussian images to determine the position and attitude of an object in a pile of objects.

Similar information is obtained from an object-modeling system designed by Mr. Philippe Brou, who has investigated the appropriate representation of rotation to make the search for the correct attitude efficient.

Mr. Brou also has designed a laser scanning device that gives accurate depth information for maps containing up to a quarter of a million points.

Dr. Brady and his associates continue to develop a new shape representation called smoothed local symmetries. Dr. Haruo Asada and Dr. Brady have implemented a fast algorithm which first locates significant features on the shape's boundary using a process analogous to edge finding, and then fits an approximation to the boundary, from which the smoothed local symmetries are computed.

Working with Dr. Brady, Mr. Scott Heide has developed an algorithm which finds the local symmetries of the full boundary, and classifies the symmetries for matching against models to perform recognition. Using local-symmetry descriptions, Mr. Steven C. Bagley is implementing a model-based system for recognizing articulated two-dimensional parts, which may be occluded or damaged.

Professors Poggio and Ullman and their coworkers are developing a theory intended to shed light on both biological and machine vision. Understanding the computational principles of vision will help us to understand our visual system and our brain. Conversely, the theoretical understanding of vision and machine application can benefit from the study of human vision because biological visual systems provide the best-known examples of efficient visual processors. Problems studied include edge detection, spatiotemporal interpolation, stereo, motion, surface reconstruction, multigrid algorithms, computation of spatial properties, intelligent signal processing and biophysics of information processing.

Professor Poggio and Dr. Vincent Torre of the University of Genoa are developing a theory of edge detection. Work continues with Dr. Allan Yuille on studying and exploiting the properties of early multiresolution representations of the image. Professor Poggio, Dr. H. Keith Nishihara and Dr. Kenneth Nielsen are studying the process of spatiotemporal interpolation for maintaining high spatiotemporal resolution and avoiding motion smear in time-varying imagery. The analysis of time-varying imagery is important since any visual processor with human-like performance must be capable of processing moving objects.

Human stereo vision continued to represent an important focus of research. Dr. Nishihara and Mr. Noble Larson have developed special hardware for doing some of the necessary computation in real time. Dr. Nishihara is developing a real-time stereomatcher for robotic applications. Dr. Nielsen examined the problem of vertical disparity and image registration in the human visual system. New matching schemes for solving the correspondence problem of stereo and motion are presently explored by Mr. Michael Kass and Professor Poggio.

The measurement of the optical flow — the field of velocities in the image — is another important visual task. Professor Ullman and Dr. Ellen C. Hildreth developed a method for computing the velocity field along contours in the image from the projection of arbitrary three-dimensional surfaces moving freely in space and deforming over time.

Professor Ullman also investigated the computations employed by the visual system in the perception of properties and relations such as closure, insideness, and connectedness. Understanding these computations is a step toward the development of a visual processor for object recognition.

Dr. Nishihara has studied noise in biological systems and its implications for stereo matching algorithms and physiological models. He has found that algorithms based on the zero crossings of the difference of Gaussian convolution do not operate well on signals with moderate noise levels even though a substantial amount of information may still be present in the sensor signals.

In another study, Nishihara and Poggio were able to demonstrate that a long held view that human stereo vision made use of hyper-acuity judgements in a very parallel fashion was incorrect. Their investigation showed that what was thought to be a very high resolution task in psychophysics had an alternative, more consistent explanation in terms of very low resolution structures in the image.

Finally, a theoretical approach to the computational mechanism used by the brain proposed by Professor Poggio has been applied, in collaboration with Dr. Koch and Dr. Torre, to the vertebrate retina and to dendritic spines. The results suggest that a single neuron may perform hundreds of independent analog operations on its inputs. A dendritic tree would be close to the ultimate in microelectronics with patches of membrane representing the fundamental units for elementary computations.

LANGUAGE AND LEARNING

Professor Robert C. Berwick extended his model of language acquisition so that almost the entire core of English syntax can be learned by a computer program that examines simple English sentences. The extended model makes it possible to test the acquisition program on languages other than English. As a first step towards this goal, two experimental parsers were designed and implemented for German and Japanese.

Professor Patrick H. Winston's theory of reasoning by analogy consists of the following parts: an English understanding module, developed by Mr. Boris Katz, that converts prepared text into relations in a semantic network; a cause-dominated matcher that finds the best possible correspondences according to the causal framework determined by the situations themselves; an analogizing module that reaches conclusions about a given situation by using a remembered precedent; and a rule builder that constructs if-then rules. During the past year, Professor Winston extended the theory to the problem of learning what things look like from functional defintions, prior knowledge, and particular examples.

Another dimension of the work involves a learning program, under development by Mr. Richard J. Doyle, that constructs behavioral descriptions of simple physical systems. Given a structural description, some background knowledge, and a list of actions which can be performed, the program, via examples, analogies, and experiments, identifies quantities in the system, associates them with physical objects, and identifies causal relations between quantities using such heuristics as temporal adjacency and physical connectedness. The learned description is then used to predict the behavior of the physical system.

COMMON-SENSE REASONING

Mr. Kenneth D. Forbus's work is on common-sense reasoning about the physical world. He has developed Qualitative Process Theory to model how changes occur in physical systems. During the past year, Mr. Forbus has been extending his techniques to perform more complex deductions, such as generating the possible future states of a system. He has also developed and implemented a theory of Measurement Interpretation which constructs theories about what is happening in a system at a particular time based on simple measurements of its parameters.

Mr. David A. McAllester has produced a reasoning utililty package that is now in use in Mr. Forbus's project, Drs. Rich and Waters' Programmer's Apprentice Project, and in several other projects at MIT and elsewhere.

Mr. John Batali is investigating programs that can understand themselves. Working in the domain of spatial reasoning, he has constructed a representation of space in which a robot can make perceptual requests to acquire information about its location and can make motions to enter different locations. To decide where it is, such a robot must use what it knows about the places it might be to generate perceptual requests and determine how to use the results to narrow down the set of its possible locations.

Mr. David Chapman is constructing a theory of learning and reasoning based on the use of naive mathematical concepts. Naive mathematics consists of such basic concepts as transitivity, groups, and successive approximations. These concepts can be used in many domains. For example, in the blocks world, ABOVE can be understood as the transitive closure of ON. Mr. Chapman's problem solver can be given a problem that it does not know enough to solve initially. By exploiting naive mathematics in reasoning and performing experiments, it will learn enough to solve the problem.

Mr. Kenneth Haase is working on computer systems which demonstrate expertise in multiple domains. These systems, called eclectic problem solvers, use a variety of methodologies and representations to function in different domains. Unlike most systems, which typically are limited to a single approach in a single domain, the eclectic problem solver moves from approach to approach and domain to domain as it comes across new problems. This research draws on the large body of existing reasoning technology and tries to build a unified framework in which many proven techniques can be implemented.

INTELLIGENT APPRENTICES

Professor Randall Davis's work has been focused in two main areas: model-based expert systems and the application of Artificial Intelligence to signal processing.

Professor Davis, Dr. Shrobe, and associates are building an expert system that uses knowledge about structure, function, and causality to diagnose faults in digital electronic hardware. Previous expert systems have typically been built from large collections of empirical associations. It was clear from the outset that such an approach would not be desirable or practical in this domain. Instead, the new system uses a detailed model of the structure and function of the device under test, allowing it to reason about how the device works, and how it fails, in a manner similar to an experienced engineer.

A second component of Professor Davis's expert systems work is a project with Mr. Reid Simmons on reasoning about geologic processes. This was inspired by earlier, traditional expert system work on a program for analyzing measurements taken on oil wells. The current effort is aimed at developing a program that understands and is capable of reasoning about geologic processes responsible for formations and deposits.

Professor Davis also collaborates with Professor Alan V. Oppenheim in exploring connections between Artificial Intelligence and digital signal processing, in the belief that techniques developed in both areas can be modified and combined to produce improved signal interpretation and signal enhancement systems. Two current foci are pitch detection and signal enhancement.

Drs. Rich and Waters study how expert programmers analyze, synthesize, modify, explain, verify, and document programs. A long-term goal of this research is to develop tools that automate the programming process. Recognizing that total automation is not close, they are developing a system, called the Programmer's Apprentice, which acts as an intelligent assistant to an expert programmer. The Programmer's Apprentice will begin by automating the more routine, straightforward parts of the programming task, leaving more of the programmer's attention free to concentrate on the difficult decisions.

Over the past year, Drs. Rich and Waters have advanced their research in two principal areas. First, the Knowledge-Based Editor, implemented by Dr. Waters, has been improved and extended. Second, in order to provide more powerful reasoning capabilities than are present in the Knowledge-Based Editor, Dr. Rich has designed a new reasoning system that will be used in the next Programmer's Apprentice demonstration. This new reasoning system, called CAKE, explores a layered approach to reasoning in which a general-purpose, predicate calculus inference engine is combined with special-purpose procedures operating on a flowchart-like representation of program structures.

EXPERT SYSTEMS FOR ELECTRONIC DESIGN

Professor Gerald J. Sussman and his associates have made considerable progress in their research into techniques and tools for very large scale integrated circuit (VLSI) design.

In one project, Mr. Gerald L. Roylance is working on a compiler for circuits. A circuit compiler is similar to a programming language compiler except that instead of compiling an abstract language to a concrete machine language, it compiles an abstract circuit design to a concrete one consisting of resistors, capacitors, and transistors.

In another effort, Mr. Daniel Weise has developed and implemented a system for the interactive and incremental extraction of circuit schematics from hierarchically represented layouts of VLSI circuits. This system enables our design system to understand and answer questions about circuits represented by layouts created using the design system.

Mr. Neil L. Mayle also has been working on simulation, investigating a method of incremental switch level simulation. A simulator of this sort allows the designer to simulate a cell when it is first designed. The information derived is memorized, thus saving the work of recomputing it during subsequent simulations.

In other VLSI-related work, Mr. James J. Cherry has been investigating circuit simulation algorithms suitable for implementation on parallel, pipelined architectures. Mr. Bruce E. Edwards has been working with Mr. Cherry on writing an electrical simulator.

A special-purpose silicon compiler, by Mr. Philip E. Agre, has been important to the development of the SCHEME-81 chip, a VLSI device for running SCHEME, a dialect of the LISP programming language. Given a small program definition, Mr. Agre's compiler produces code specifying the layout of a SCHEME-81 compatible chip to implement that function.

Also, Mr. Jonathan D. Taft has been working on building a small SCHEME computer for testing our chips. It uses a Motorola 68000 design module as a front-end processor for performing I/O, for user-level arithmetic, for character manipulation, and for console control and debugging of the SCHEME system.

Finally, in the analog domain, Mr. Andrew Ressler is developing an expert program that will be able to design operational amplifiers. It is being developed to learn how to integrate the formal techniques of circuit design with the informal rules used by expert circuit designers.

MUSIC COGNITION

The Music Cognition Group, directed by Professor Minsky, is investigating the cognitive foundations of musical behavior using the methods of Artificial Intelligence. The general objective is to extract and represent expert knowledge about music by building computational models of the cognitive processes involved in composing, performing, and listening. Currently, the group's activities are concentrated in two areas – the automated composition of music in well-understood historical styles, and the study of improvised keyboard music. These efforts provide a focus for research in musical learning, problem solving, reasoning, and knowledge representation.

Dr. Kornfeld has developed a program that composes sixteenth-century species counterpoint from a database of rules described using the PROLOG programming language. Mr. John Amuedo has developed a system for generating musical scores from compact symbolic descriptions. These descriptions embody several concurrent points of view which represent such musical concepts as theme, imitation, sequence, and harmonic plan.

Mr. Amuedo has also been developing a programming language called AP-LISP (Array Processing LISP) for programming applications that mix symbolic and array-oriented numerical computations. AP-LISP allows many iterative computations on vectors and matrices to be described in terms of array operators combined using ordinary functional composition.

Mr. David Levitt is studying the process of acquiring *stylistic* knowledge the way many musicians do: by studying increasingly complex listening examples and adapting them to new contexts, through analysis and partial imitation. His immediate goal is to develop such a learning model for several solo jazz piano genres, including *stride*, left-hand patterns, and *block chord* voicings of a melody.

Several researchers have been developing LISP Machine based tools for collecting, editing, and transcribing improvised keyboard music. Mr. Chris Schneider is developing an editor for capturing and manipulating performance schedules recorded on a specially instrumented piano keyboard. Mr. Naoki Abe demonstrated a program for classifying onset time differences in improvised performance schedules. His program used a combination of clustering techniques and perceptual constraints to generate a printed score from an improvised performance. Mr. Matt BenDaniel developed a technique for transcribing keyboard performances using a machine-generated metronome. Mr. Steve Strassman is developing a program for annotating performance schedules so they can be translated directly into common-practice music notation.

In related work, Mr. Henry Lieberman has been investigating the applications of object-oriented parallel programming to musical problems. Mr. David Saslav is working on a program that realizes a figured-bass accompaniment from a set of harmonic constraints and voice-leading rules. Professor Minsky is developing several new theories of musical function, linked to his work on exploratory learning, humor, and the redirection of emotional responses.

INTELLIGENT SUPERCOMPUTING

The Connection Memory Machine is a computer that performs fast, parallel searches through networks, a fundamental, rate-limiting step in many problem-solving programs. Led by Mr. Hillis and Dr. Knight, work on this machine is a major effort.

During the past year a prototype machine has been designed and a packaging scheme has been selected. Thus we are almost ready to begin the implementation of prototype hardware. Because the design requires parts to be duplicated in great numbers, yield, testing, packaging, and reliability are receiving careful attention. The large scale of the project forces the development of new methodologies and design tools.

Mr. Alan Bawden has utilized applicable parts of conventional compiler technology to implement a prototype language for programming massively parallel machines such as the Connection Machine. The resulting language is still very simple, but serves as a convenient basis for extension languages that support higher-level models of the connection memory machine.

Initial experiments with using this language have revealed common Connection Machine programming practices and principles that will help to design future Connection Machine languages. Mr. Bawden is currently working on a successor to this prototype language whose compiler will have a better understanding of synchronization techniques so as to relieve the programmer of some of the burden of dealing with synchronization himself.

Another approach to creating parallel systems is that of Professor Carl E. Hewitt and his associates. They have developed actor theory, a rigorous abstract theory of parallel systems, that provides a foundation for the construction and analysis of highly parallel problem-solving systems. Highlights of the past year include the development of the concept of Open Systems, which embodies notions analogous to the forces working in human societies and brings those notions to bear on parallel computing. These notions include the idea of due process, by which procedures work both for and against a goal; temporal commutativity, by which knowledge can be acquired in any order without affecting the ultimate outcome; sponsored work, by which decisions are made about how resources are to be allocated; and the open-world assumption, which forces systems to work with incomplete and inconsistent knowledge.

Working with Professor Hewitt, Mr. Lieberman has completed a preliminary version of the Tinker System for concrete programming. Tinker enables a user at a work station to develop general procedures by abstracting from specific instances of steps performed on concrete examples at the work station. Mr. Lieberman and Professor Hewitt also have developed a real-time garbage collection algorithm based on the life time of objects.

PATRICK HENRY WINSTON

Center for Advanced Engineering Study

The rapid pace of technological advance and accelerated international competition have increased general interest in continuing education for engineers. The Center maintains four major programs to meet this increased interest:

- The Advanced Study Program -- under which engineers in professional practice, teaching, or technical management come to the Center for a semester or a year of individualized study.

- The Video Course Program -- containing over 1,000 videotapes which bring technical information to the place of work.

- The Conference and Seminar Program -- which develops short courses, workshops, and seminars enabling practicing engineers to study subjects intensively for short periods of time.

- A Research and Development Program -- which seeks better information about the needs of practicing engineers and new techniques for meeting them.

Advanced Study Program

This is an on-campus program that enables engineers and scientists to work in depth in technological areas of their choice. The program serves technical managers who wish to understand developments that bear directly on their problems, men and women who seek competence in depth at technological frontiers, and those who desire to strengthen their technological base. This year there were 69 Fellows from 17 countries. The Advanced Study Program (ASP) is directed by Dr. Paul E. Brown.

Fellows of the program are affiliated with the Center for one or more terms. They may develop courses of study to meet their individual needs or may participate in specialized programs. Included in ASP are several specialized programs such as Air Transportation, Systems Reliability and Risk Analysis, as well as the Visiting Engineer Program. The Visiting Engineer Program is similar to ASP except that the emphasis is on participation as colleagues in research with faculty members.

The programs coincide with the normal academic terms and year. Special weekly seminars are planned and conducted during the fall and spring terms especially for Fellows of ASP and participants in the Visiting Engineer Program. Each term several special subjects of broad interdisciplinary interest are also offered within the Center for participants in the programs.

Grades are recorded for all MIT subjects taken for credit. A certificate is awarded following satisfactory completion of a Program. Fellows also may apply for admission to the MIT Graduate School.

This summer we are offering a seven-week intensive course on "Air Transportation -- Management, Economics, and Planning," jointly with the Flight Transportation Laboratory of the Department of Aeronautics and Astronautics. The course meets all day, five days a week. There are also evening sessions. Sixteen men from 11 countries are attending the course.

Video Course Program

Finite Element Methods in Engineering Mechanics, a twelve-tape video course by Professor Klaus-Jurgen Bathe, was published in September 1982. Intense pre-publication interest in Finite Element Methods was followed by strong acceptance and utilization within American industry.

The Deming Tapes: Quality, Productivity, and Competitive Position, and landmark textbook of the same title were published by the Center in January, 1983. During the last six months of fiscal 1983, over one thousand US businesses utilized the materials.

Introduction to Analog and Digital Signal Processing, a new video course by Professor Alan V. Oppenheim, was taped during fiscal 1983. The course is presently in post-production; publication is scheduled for mid-1984. Projections indicate that the course will reach over 50 thousand engineers during its lifetime.

The video courses are being used with great success by industry and government agencies, reaching over 35 thousand participants annually. We continue to work on the objective of providing video-based continuing education at a distance.

The Conference, Seminar, and Short Course Program

The Conference and Seminar Office was established in 1977 to provide professional marketing and logistical support for the growing number of technical continuing education conferences, seminars, and non-credit short courses at MIT. While the majority of programs offered through the Seminar Office are sponsored by the School of Engineering, the office is prepared to handle continuing education programs from any area of science and technology, and is designed to manage these programs on and off campus -- in the United States and throughout the world. The Seminar Office has received the approval of both the Engineering and Academic councils as a recognized office of continuing education at MIT.

The heavy demand for continuing education offerings has resulted in a growing number of programs at MIT. A few of the 1982-83 programs included: "Managing Productivity II: Measuring the Effectiveness of Knowledge Workers" sponsored by the Laboratory for Manufacturing and Productivity; "Advances in Nuclear Systems Thermal Analysis II" sponsored by the Department of Nuclear Engineering; "Microprocessor Applications: Software and Hardware Techniques" sponsored by the Center for Advanced Engineering Study; "Third International Conference on the Behavior of Offshore Structures" sponsored by the Department of Civil Engineering; "Transportation Systems Management and Analysis" sponsored by the Center for Transportation Studies (CTS); "Forecasting Transportation Demand" sponsored by CTS; "Railroad Operations, Planning and Management" sponsored by CTS; "Microcomputers in Transportation" sponsored by CTS; "Regionalism in International Air Transportation" sponsored by the Flight Transportation Laboratory; "Managing Systems of People and Machines for Improved Quality and Productivity" sponsored by the Center for Advanced Engineering Study.

During 1982-83, more than 34 foreign countries and 48 states in the US were represented at continuing education offerings from the Seminar Office. The 500 percent increase in programs during the past 24 months is an indication of the interest in continuing education meetings. Therefore, the number of program offerings is certain to increase substantially during 1984.

Research and Development

This year the Center shifted its emphasis in research from energy conservation to the problems associated with commercial competitiveness in international markets. One of the keys to increased strength in this area is increased quality and productivity. With the production of the Deming tapes several members of the staff have taken a greater interest in this subject. Six papers analyzing the essence of Deming's approach and its application were prepared. A large number of visits was made to industries interested in applying Deming's approach and as a result, several new videotapes are now planned. A research assistant is now collecting educational materials from industry. This data base is of great value to companies which visit the Center to learn how better to teach the new methods to their employees and suppliers. A visit was made to six companies in Japan which had won the Deming Prize. Their organization and practices were studied and summarized for the benefit of the many companies which are now visiting the Center to discuss quality and productivity management.

An informal committee of persons from Industry, Academia and Government was formed to examine the potential to establish a prize in the USA similar to the Deming Prize in Japan. The proposal has been incorporated in materials presented to President Reagan's Cabinet for approval. Initial planning is underway for the creation of a US equivalent to the Japanese Union of Scientists and Engineers to promote education and training in management for quality and productivity.

A special program of study in this field is being developed. The first "fellow" from industry was accepted last year to work in this field. His studies revealed an interesting connection between the derivatives of the learning curve and the use of statistical quality control methods.

Based upon these studies, a new subject "Managing Systems of People and Machines for Quality and Productivity" will be offered in the School of Engineering in the Fall term 1983. Influencing undergraduate and graduate education is an important by-product of the Center's research and development program.

MYRON TRIBUS

Center for Policy Alternatives

The Center for Policy Alternatives (CPA) is dedicated to both research and education in science and technology policy. In January 1983, Professor Nicholas A. Ashford succeeded J. Herbert Hollomon as Director of the Center. Since its founding in 1972, CPA has been suggesting alternative courses of action to government, industry, labor, and educational institutions that are addressing complex socio-technical problems. CPA has been particularly concerned with industrial innovation--the way new technology is developed and introduced--and with technology's effects on society.

CPA's objectives are to identify and study important emerging social issues in which science, technology and engineering play a significant role, to assess the consequences of established institutional policies and develop alternatives available to decision makers, and to provide faculty, research staff, and students with research and training opportunities in policy formulation and analysis. The Center especially welcomes the participation of faculty, students and staff from the departments, other centers, and laboratories in joint research efforts. CPA faculty and staff are active participants in the Technology and Policy Program in the School of Engineering.

The CPA approach to policy analysis is multidisciplinary, involving specialists from a wide variety of backgrounds, including engineering, science, law, economics, political science, and philosophy. Research at the Center often requires the development of new research methodologies that both encompass and extend traditional methods. Legal analysis is an important dimension of the Center's work, and law and technology courses at MIT have been developed and are taught by Center faculty and staff.

Many CPA studies are international in scope and use a comparative approach, or focus on the experience of a single foreign country, often with the collaboration of foreign research centers or universities. CPA research reports and publications are distributed to leaders in government, industry, labor, education, public interest groups, and to other research centers throughout the world.

During the past year CPA continued its specialization in technology and industrial policy; regulation and technological change; environmental, health, and safety regulation; and issues related to technology, labor, and the consumer.

RESEARCH

Technology & Industrial Policy in the U.S.

Dr. Christopher T. Hill continued Phase II of his NSF project assessing the feasibility of new science and technology indicators. Work during the year has centered on a test of approximately ten new indicators through a survey of over one hundred U.S. manufacturing firms. The objective of the project is to assess the feasibility of additional data collection and analysis for producing new science and technology indicators that could enhance the nation's capability to monitor the rate and direction of technological innovation and change. The final report is entitled New Indicators of Industrial Innovation.

Professor Utterback published this year the results of his follow-up study analyzing the potential commercial and foreign trade impacts of the Sea Grant Program. In the earlier research, performed in 1976, 77 projects were examined with an estimate of their sales profits and impact on balance of payments for 1980. 59 of these were reexamined, revealing that 29 matched the 1976 predictions, six did better than projected, and 24 turned in a weaker than projected direction.

Following her study of Massachusetts high-technology, Dr. Nancy Dorfman has begun an NSF-sponsored study of the contributions of small enterprises in high-technology electronics industries to account for their success as innovators. Focus of the study will be on the conditions, the size and the age of successful firms. The project will build a basis for formulating a theory that will predict the conditions under which small firms will turn out to be the main innovators in an industry.

The remanufacturing project of Mr. Lund continued this year with publication of several papers, among them a chain saw feasibility study and guidelines for establishing independent remanufacturing enterprises. In process at this time is the development of guidelines for Original Equipment Manufacturers (OEMs) considering remanufacturing. Mr. Lund has begun a feasibility study of the application of remanufacturing to developing countries for the World Bank with a state-of-the-art paper on remanufacturing. In December he held a national conference with CAES on remanufacturing in which there were over 80 participants. He also supervised three master's theses on remanufacturing topics: "Remanufacturing of Motorcycles and Motorcycle Parts" (Enrique Suarez), "Truck Remanufacturing in Puerto Rico" (Tomas Gonzalez), and "Remanufacturing in Turkey" (Arif Alauddin).

Technology & Industrial Policy in Other Countries

Industrial Innovation in Sweden:

In 1980 the Swedish National Board for Technical Development invited CPA to study industrial innovation in Sweden. The project was completed with the publication of the report, The Role of the National Board for Technical Development. This board (STU) is the main instrument of government policy for encouraging industrial and technological innovation in Sweden. STU was reorganized in 1977 to promote innovation as a force in Sweden's industrial renewal. Starting with the 1977 mandate, Dr. Andrew Martin examined STU's organizational and operational requirements and the future development needs to continue it role. Extensive interviews at STU and at other institutions (governmental, industrial, and academic) were used along with written sources.

STU also invited Professor James Utterback to prepare a report of research on innovation. Sweden has a number of outstanding researchers and unique advantages in innovation research. Professor Utterback examined the clusters of ongoing research and research issues which are most important with respect to the growth and development of industry in advanced economies such as Sweden and the United States.

The declining competitiveness of many industrial sectors in Sweden, other industrialized countries of Europe and in the United States is a subject of intense public and governmental concern in these countries. The Salen Foundation of Sweden has funded a CPA study with Dr. K. N. Rao as principal investigator which will develop indicators of mature industries in Sweden. It will focus not on past performance or present malaise but on the comparative level of maturity of Swedish industry with other OECD countries on a sectoral basis and its vulnerability to competition in the decades ahead.

Technological Development in Portugal

This two-and-a-half-year comprehensive study had as its objective a thorough analysis of the scientific and technological infrastructure of Portugal to support industrial innovation, the analysis of entrepreneurial attitudes and behavior towards innovation, and a technological assessment of more traditional as well as several new 'high' technology sectors of potential importance to Portugal. The study group included members of the Portuguese Laboratorio Nacional de Engenharia e Tecnologia Industrial (LNETI) and CPA. Some one hundred enterprises of different sizes and ownership were interviewed in the study. A large section of the Portuguese entrepreneurial, academic, and government community was consulted in an effort to obtain national perceptions and viewpoints on problems and solutions.

The study drew to a successful conclusion in May 1983, when the findings and recommendations of the study were announced to the nation by the Socialist Government that took office during the month. The ten-year mid-term Technological Development Plan calls for investments of about 240 million dollars over a 10-year period in a series of projects in which the government and industry would participate in financing and project implementation.

A financial intermediary organization tentatively called "Fund for the Support of Technological Innovation" would provide risk capital to support innovation in industry. The plan also recommends support to a series of technological centers strategically located near client enterprises in the traditional sectors to provide technical assistance (ceramics, textiles, cork, metalworking, etc.) to improve productivity and product quality to enable them to successfully compete in international markets. An Agency for the Promotion of Advanced Technology would provide prompt financial and project appraisal and development assistance to enterprises, universities, and research institutes to develop new technology and diffuse it in Portuguese enterprises through demonstration projects and research

collaboration with other EEC countries. A measure of the success of the planning effort is that the new government in Portugal has already established institutional mechanisms for speedy implementation of the plan's recommendations.

For CPA, the project represented one of the more comprehensive research and planning projects it has undertaken, and it involved most of the senior staff of the Center. The project was directed by Dr. K. Nagaraja Rao who acted as principal investigator. Among the senior CPA staff, Messrs. J. Herbert Hollomon, Christopher Hill, John Hansen and George Heaton were involved substantively in several research tasks of this project. Mr. Sohail Bengali (graduate student in the Technology and Public Policy Program at MIT) led a team of research assistants which included Ms. Satareh Razmara (a research assistant), Mr. Richard Arnold and Mr. Christian Egenhofer (research interns at CPA from the University of Konstanz, West Germany). Prof. Raymond Baddour, Professor of Chemical Engineering, was one of three consultants who provided expert assessments of the industrial sectors analyzed during the study.

Robert T. Lund and K. N. Rao as co-principal investigators conducted a study for the Comissao Para Estudo do Sector Electromecanico (CESEM) of Portugal entitled Applications of Microelectronics in the Metalworking, Textile and Other Industrial Sectors in Portugal, a state-of-the-art review of the use of microelectronics in Portuguese industry with particular focus on the needs and opportunities for the electro-mechanical sectors. (This project complemented the sectoral analysis under the previously mentioned larger CPA/LNETI study of technological development in Portuguese industry.) The application of microprocessors in the textile industry was surveyed for the study by Professors Perry L. Grady and Gary N. Mock of the State University of North Carolina. Dr. David Handt of MIT's Department of Mechanical Engineering contributed to the study. Mr. Kuman K. Aragam, former Assistant Director of Central Machine Tool Institute in India, acted as a consultant. Mr. Sudhakar Keshavan, graduate student in the Technology and Public Policy Program at MIT, was a research assistant for this study.

Based in part on previous work by CPA, the report includes recent data and developments in this fast-changing field as well as perceptions of industry obtained by consultation with manufacturers of microelectronic components and systems. Policy implications and strategic considerations for Portuguese entrepreneurs and government planners were outlined. It is obvious from the review that the rate of change in this technology is so fast and its diffusion so pervasive that it is already being called an infrastructural technology.

Regulation & Technological Change

The NSF-sponsored study of innovation in the pharmaceutical industry was an in-depth analysis of three therapeutic areas to reveal associations between specific kinds of regulatory and non-regulatory stimulus conditions, drug development process types, and innovative progress. A data base has been compiled for the period 1950-1981 to analyze trends in drug innovation. Examining three therapeutic classes of drugs to isolate the changing patterns of drug innovation which are attributable to regulatory influences after 1962, Dr. Hattis, project manager, Dr. Ashford, principal investigator, and the research team have found that there are fewer new drugs appearing, but they are of greater therapeutic value than those appearing prior to 1962.

Environmental, Health and Safety Regulation

Professor Nicholas Ashford and CPA researchers Dale Hattis, W. Curtiss Priest, and Christopher T. Hill completed work last year on an in-depth study entitled Analyzing the Benefits of Health, Safety, and Environmental Regulations. This report views estimating benefits as a three-step process involving risk assessment; a description of the resulting social consequences of exposure to environmental, health, and safety risks; and finally, the valuation of those consequences. The report offered methodologies for improving those three steps, addressed the need for incorporating an assessment of the effectiveness of the implementation of and compliance with federal regulation, and discussed the necessity of establishing appropriate baselines against which to estimate the effects of regulation aimed at the reduction of risk.

The last decade gave rise to a considerable diversity of government legislation designed to control safety and health hazards. These laws incorporate various value judgements about the acceptability of risk. Professor Ashford has begun a study, Criteria for the Design of Coherent Sets of Social Controls for Health and Safety Hazards, to elucidate the underlying values and ethical principles reflected in the current health, safety and environmental legislation and in administrative and judicial actions implementing that legislation. Dr. W. Curtiss Priest is the project manager.

The cooperative agreement with the Office of Toxic Substances at EPA moved into its second year with Dr. Ashford as the principal investigator. Over the past few years the EPA has devoted considerable effort to developing priority scoring systems to help recognize important toxic substance control problems. A priority scoring system is to help direct agency effort to projects where there is the largest net social benefit from the use of agency resources. Dr. Dale Hattis, as project manager, conducted a study entitled Construction of a Common-Sense, Easily Used Priority Scoring System for Toxic Substance Integration Efforts to be used by the Office of Toxics Integration (OTI). The new scoring system uses the potential human health damage from current production of chemicals, the potential contribution of OTI coordination efforts in shaping abatement measures, and a weighting factor selected by OTI personnel.

The Office of Toxic Substances of the EPA has several divisions that collect information related to the toxicity of chemicals. For the last three years, the Management Support Division has been taking this information and developing a computer database that incorporates data in specific data fields (called SPHERE). Development costs have been high and EPA management could not determine whether the effort should be continued or redirected. Dr. Curtiss Priest at CPA was asked to evaluate the SPHERE activity and determine the relationship of SPHERE to both the internal activities of EPA and other database information systems in the U.S. and abroad. He has recently completed a report, An Evaluation of the SPHERE Pilot System: Appraisal of Its Utility, Scope, and Direction, in which he discussed issues of management, technology, benefits, and costs. A fundamental conclusion was the need for EPA to incorporate its information system developments as a more central component of their management approach. This investigation builds on research on data-base management systems which lead to a new research tool designed by Dr. Priest (see Information Dissemination below).

Dr. Dale Hattis completed a study of the implementation of the occupational lead exposure standard for the congressional Office of Technology Assessment. Working with Clark University, he found that the air lead and blood lead levels have been reduced, roughly consistent with OSHA's predictions. The study showed that the most effective measures are those which reduce air lead levels and so the report recommends implementation of the current standard for air lead levels. Also recommended is a deliberate societal consensus-building process for arriving at what is deemed feasible.

The U.S. Minerals Management Service (MMS) in Virginia has several tasks relating to the management of environmental and safety risks of offshore development. Dr. Hill has conducted a study for them based in part on an examination of the uses of risk analysis for offshore technologies by firms, government agencies, and consultants in the U.S., Norway, and the United Kingdom. It includes both a review of available reports and documentation and interviews overseas. The inquiry is being combined with an analysis of the functions of MMS to define the potential contributions of risk analysis. The project is being carried out in close cooperation with the Technology Assessment and Research Program of MMS under a contract from Sandia National Laboratory in New Mexico.

Technology, Labor, and the Consumer

As part of the ongoing program of modeling and analysis of the supply and demand for engineers and other technical labor, Dr. John Hansen revised the CPA study on Inter-Occupational Mobility of Experienced Scientists and Engineers. The study constructed models which attempt to forecast specific probabilities of switching between professions per unit time. The results show a strong wage effect: where wages are increasing most rapidly, the net survival rate is larger. Younger cohorts are more sensitive to wage pressures; older cohorts have more specific capital invested and have less to gain from switching. The study showed that engineers responded more strongly to wages than did scientists.

For the U.S. Department of Labor, Dr. Hill has been principal investigator analyzing the labor productivity performance of the U.S. manufacturing industry of the past two decades. The project has assessed conventional theories of the underlying causes of differential productivity performance and the testing of new factors as the competitive pressure of rivalry from other firms, the stage of development, and the characteristics of the organization of firms that influence their capabilities to engage in both risk-taking and adaptive behaviors.

In the field of office automation, Dr. Marvin Sirbu wrote Understanding the Social and Economic Impacts of Office Automation. After looking at office automation and employment, ergonomics, and the impact of office automation on the nature of office work, Dr. Sirbu suggests a conceptual framework for assessing these effects. Key to this is achieving a clear idea of the complexity of defining office functions and office automation. Further clarification will come from research in which the separate impacts of technology and organizational change have been accounted for.

The Environmental Scanning Association (ESA), a consortium of major businesses, commissioned a study of emerging manufacturing technologies and an evaluation of their impact on the workforce. Mr. Lund led the study, Connected Machines, Disconnected Jobs, which began with the premise that changes in manufacturing technology are evolutionary with time lags betweeen discovery and adoption. The time lags made it possible to interview senior manufacturing technologists who understand the trends likely to be of importance to their firms in the next decade. Computer integrated manufacturing systems with impact on labor displacement, job design, and retrofitting existing plants were highlighted in the survey.

EDUCATIONAL ACTIVITIES

Students perform a major role in CPA research and are involved in most projects undertaken at CPA. This involvement provides students with training in policy formulation and analysis while enriching CPA research products. During the past academic year, 17 graduate and undergraduate students from MIT and other universities participated in CPA research.

Many of the MIT graduate students who work at CPA are master's candidates in the Technology and Policy Program (TPP), an interdepartmental program in the School of Engineering in which students take courses in economics, law, government, and a technical concentration of the student's choosing. Since the program's founding in 1976, many TPP students have received policy analysis training at CPA. Professor Ashford, Dr. Sirbu, and Dr. Hill served on the TPP faculty steering committee.

During the past academic year, CPA staff members taught three graduate courses in the master's degree program in the Management of Technology (MOT). The program is sponsored jointly by the Sloan School of Management and the School of Engineering. As part of the MOT program, four researchers at CPA (Dr. Ashford, Mr. Heaton, Dr. Hill, and Dr. Hollomon) developed and taught for the second year a course in Government and the Management of Technology. The seminar examines the changing role of government in shaping and directing the management of technology in the civilian sector of the economy.

CPA staff taught nine subjects in the School of Engineering (Ashford, Heaton, Hill, Lund, Sirbu, and Utterback); three in the School of Management (Ashford, Heaton, Hill, Hollomon, Rao, and Utterback); and two in the School of Humanities and Social Science (Hill and Sirbu).

One student and one former student (now a researcher) from CPA were chosen as delegates to the recent International Student Pugwash Conference on Science, Technology, and Global Responsibility--a meeting of students and senior participants from around the world concerned with issues of the social and ethical implications of science and technology.

INFORMATION DISSEMINATION

CPA began publication of the biannual review, Policy Choices: A Review Discussing Technology, Engineering, and Social Policy in the fall of 1980. Policy Choices, edited by George R. Heaton, is a twice-yearly publication. It reports on current activities at CPA and is intended to stimulate discussion among people in government, industry, education, labor, and public interest groups on the role of technology and engineering in society.

Policy Choices this year had a lead article by Dr. Ip-Sam Kim, president of the Korea Technology Development Corporation (KTDC) and another by Dr. Jack Baranson, "Technology Transfers and National Security," drawn in part from his recent book, The Japanese Challenge to U.S. Industry. Circulation continues to increase, a fact which contributes to the increase in circulation of CPA research reports as well.

CPA Bibliographic Management System (BMS), a computer-based storage and retrieval system designed by Dr. Curtiss Priest and based on the FOCUS data-base management system, is now in its fourth major version. It contains 14 substantive bibliographies: innovation, toxic substances, regulation, benefits, values, transportation, trade secrets, medical, reindustrialization, chemicals, lead, and wellbeing. Interest in this powerful research tool, which organizes and searches bibliographic material and generates bibliographies, continues to grow within CPA and the larger MIT community, as well as outside of the

Institute. BMS is now being used by MIT's Technology Adaptation Program and by the Aga Khan Program for Islamic Architecture. BMS software is available for license from MIT, and current outside users include Brown University, the Insurance Company of North America, and Cheesbrough-Ponds, Inc.

Under the direction of Senior Research Associate, Dr. John A. Hansen, the CPA Seminar Series was begun this spring. This series was established as a means of communicating the range of research activities within CPA. For the present, the speakers are those of research staff, students, or visiting scholars from within the Center itself. The luncheon series is announced in Tech Talk and open to the public. Its purpose is to increase awareness to the MIT community of work being done by the Center. Presentations thus far have been "Innovation in International Telecommunications and Multi-National Companies" by Visiting Fellow Christiano Antonelli, "Revised Forecasts of the Labor Market for Engineers" by John Hansen, and "Quantitative Risk Assessment for Chemical Health Hazards" by Dale Hattis.

CPA also disseminates its work through researchers giving external talks and serving on committees and advisory bodies. Such activities add up to a substantial effort to ensure that decisionmakers in both public and private sectors are aware of the policy alternatives that derive from CPA research. CPA is continuously assessing ways of reaching decisionmakers and ensuring that an appropriate balance is maintained between doing research and communicating its results.

PUBLIC SERVICE

During the past year, members of CPA continued to serve on public or professional advisory committees and testify before Congress on public policy issues. In addition, several staff members served as advisors and consultants to private firms, labor organizations, and public interest groups.

Dr. Ashford participated in a National Science Foundation symposium on law-science cooperation under the National Environmental Policy Act, and, with four other experts on environmental regulation and policy, he was a Roundtable Discussant on the topic, "Science & the EPA," sponsored and published by Environment magazine.

Twice in the past year, Dr. Ashford travelled to Europe for meetings. In November he presented an invited paper at the international conference in Rome on "Workers' Participation in Technological Choices Affecting Health & Safety" sponsored by the Italian National Research Council. Late this spring he was an invited participant in the first international meeting sponsored by the Center for Mediterranean Studies in Athens: "Stagnation in the West: The Challenge for Democratic Planning." He completed his trip with the presentation of an invited paper for the Royal Society of Medicine in London for their Anglo-American Conference on Pregnant Women at Work. Dr. Ashford's paper was entitled, "The Use of the Law for Controlling Reproductive Hazards in the American Workplace." Earlier in the spring he travelled to the American Association for the Advancement of Science (AAAS) meetings in Detroit where he presented his paper, "The Role of Advisory Committees in Resolving Regulatory Issues Involving Science."

Other professional activities during the year included the American Arbitration Association meeting in Boston, "Critical Issues in Collective Bargaining & Arbitration: Health and Safety Challenges in Arbitration," in which Dr. Ashford was a panel participant; meetings at the Hastings Center in New York for NSF-EVIST Project Directors on the topic of "Ethical & Value Issues in Occupational Health;" and a meeting sponsored by the Center for the Study of Responsive Law to develop the Center for Universities in the Public Interest in which he participated as a panel member.

Dr. Rao, an active member of the American Institute of Chemical Engineers, organized a plenary session on Case Studies of Personal Involvement in Overseas Engineering Projects, a presentation by the International Division of the American Society for Engineering Education in its Annual 1983 Convention held in Rochester, NY. Earlier in the year he chaired an Evaluation Committee of the University of Houston to recommend future dimensions of development for the Industrial Technology Department of the College of Technology. During the past year, Dr. Rao also served as a member of a World Bank appraisal mission to Korea on graduate education and research, and more recently he was a member of an OECD mission to Turkey to review the initial draft of Turkey's first science and technology plan. Dr. Rao continues to serve on the MIT Ad-hoc Committee on Boston desegregation and the Institute's collaboration with the Mario Umana Technical High School.

Dr. Marvin Sirbu presented several papers during the year. In August of 1982 and again in January of 1983, he participated in the Conference on Fiber Optics and Broadband Communications, "Communications in the Automated Office;" in November of 1982 he spoke before the Social Impacts Advisory Committee of the Japanese Fifth Generation Computer Project in Tokyo, "Social Issues in Fifth Generation Computers;" in March of 1983 he spoke at Carnegie Mellon University, "The Future of Local Telecommunications: Technology and Economics in the Local Loop;" and in May of 1983 he spoke at the J.F. Kennedy School of Government at Harvard, "The Effects of Government Policies on New Business Opportunities in Telecommunications."

For the past year, Professor Utterback served on the National Academy of Sciences panel on Very High Speed Integrated Circuits Program and was the US editor of Research Policy.

George Heaton and Herbert Hollomon testified at hearings on strategic technologies, U.S. Senate, Committee on Commerce, Science and Transportation, June 23, 1983.

In April 1983, Andrew Martin presented two papers: one was entitled "Problems and Prospects of the New Social Democratic Government in Sweden" at the Center for European Studies, Harvard University; and the other was entitled "Social Democracy Without Growth? Economic Constraints and Strategic Dilemmas in Sweden" at the University of Wisconsin in Madison.

Nancy Dorfman presented a paper at the Small Business Research Conference in Waltham sponsored by the Small Business Resource Development Center and the Small Business Foundation of America. The paper was entitled, "Small Enterprises and Economic Growth of a High-Technology Complex: The Case of Route 128."

Robert T. Lund testified before a Congressional subcommittee on the subject of remanufacturing based in part on his study for ESA on computer-based automation and the workforce. He also assisted in the development of a Manufacturing Systems Engineering Curriculum at MIT proposed to IBM for funding.

Caroline Whitbeck, on the Editorial Board of Hypatia since 1982, was invited to give several addresses during this past year. In addition to speaking at the University of Maine/Orono, Wellesley College, the Symposium on Ethics in Psychotherapy held at Brown University as part of the Program in Biomedical Ethics, and the Boston Colloquium for the Philosophy of Science, Symposium on Feminism and Science, she read her paper, "What is Medical Ethics?" at a special session on medical ethics for the Society for Medical Decision Making, and "The State of the Art in Bioethics," for the American Public Health Association Meetings in Montreal.

STAFF PUBLICATIONS

Both Dr. Nicholas Ashford and Dr. Marvin Sirbu this past year received a Case Selection Award by the Editorial Board of the Public Policy and Management Program for Case/Course Development (Harvard Business School Cases). Dr. Ashford's case was entitled, "Regulating Vinyl Chloride in the Workplace;" Dr. Sirbu's was "Electronic Mail and the Postal Service (A) and (B)." In 1980 Dr. Sirbu won the award for his case entitled, "Chlorofluorocarbons and the Atmosphere."

CPA staff members contributed to books, journals, and CPA reports during the past fiscal year. Some of these publications included the following:

Ashford, Nicholas A., "The Role of Advisory Committees in Resolving Regulatory Issues Involving Science and Technology: Experience from the Occupational Safety and Health Administration and the Environmental Protection Agency," Resolving Regulatory Issues Involving Science and Technology, Nyhart and Carrow, eds., Lexington Books (1983), pp. 165-173; "Risk Assessment and the Design of Policy for Worker Protection," American Journal of Industrial Medicine 3: 241-242, January 1983; "Emerging Issues in the Role of Scientific and Technical Information in Environmental, Health, and Safety Regulation," presented at the Fourth Annual Research Conference for the Association for Public Policy Analysis and Management (APPAM), October 28-30, 1982; "Legal Mechanisms for Controlling Reproductive Hazards in the Workplace," Occupational Health & Safety (February 1983), pp. 11-12, 39-42; "Federal Regulation of Toxic Substances in the Workplace," Safety Evaluation and Regulation of Chemicals, F. Homburger, ed. (Basel, 1983), Proceedings of the First International Conference on Safety Evaluation and Regulation of Chemicals, Boston 1982, pp. 58-65; "A Framework for Examining the Effects of Industrial Funding on Academic Freedom and the Integrity of the University," Science, Technology and Human Values, April 1983.

Ashford, Nicholas A. and Christine J. Spadafor, "Human Monitoring: Scientific, Legal, and Ethical Considerations," Industrial Relations Law Journal, to appear in January 1984.

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FACULTY, STAFF, AND STUDENTS

CPA's permanent staff includes 10 research staff, three faculty, eight temporary research specialists, two administrative staff and two support staff. In addition to the permanent staff, 20 students and six visiting researchers worked on CPA research during the past year.

Faculty and Staff Changes

Nicholas A. Ashford was appointed Director of the Center, succeeding J. Herbert Hollomon who served as Director for the past ten years. Dr. Ashford is Associate Professor of Technology and Policy in the School of Engineering where he teaches courses in technology and law. He holds both a Ph.D. in physical chemistry (1965) and a law degree (1972) from the University of Chicago, where he also received graduate training in economics.

Dr. Ashford is the author of a major work for the Ford Foundation, Crisis in the Workplace: Occupational Disease and Injury, published by the MIT Press. For several years he was a public member and chairman of the National Advisory Committee on Occupational Safety and Health, and also served on the EPA Science Advisory Board. He was recently elected a Fellow of the American Association for the Advancement of Science.

Dr. Ashford's research interests include the design of government policies for encouraging technological innovation, regulatory law and economics, and labor's role in technological change. He developed a methodology for decisionmaking in the regulation of chemicals for the US Council on Environmental Quality and for the Environmental Protection Agency. He is currently investigating the effects of regulation on technological innovation in the chemical, pharmaceutical, and automobile industries. Under Dr. Ashford's leadership the Center will continue both its research emphasis on technology and its effect on society, and an active role in the education of students in science and technology policy.

Professor J. Herbert Hollomon left CPA in January and retires from MIT in August. Professor James Utterback became the director of MIT's Industrial Liaison Office on July 1, 1983. Christopher Hill is going to the U.S. Congressional Research Service, Library of Congress, in August as Senior Specialist in Science and Technology Policy. Charles C. Caldart, J.D., M.P.H., joined the Center as a research attorney and has been working on problems of environmental, health, and safety regulation.

Visting Research Staff

Dr. Bo Carlsson from the Industrial Institute for Economic and Social Research in Stockholm continued his research on the American tool industry until returning home in December. Professor Guy Robinson from Southampton University spent the year as a visiting scholar writing on the topic of people and computers as background for policy analysis of artificial intelligence. Professor Christiano Antonelli, a Rockefeller Foundation Fellow from the University of Calabria, Italy spent most of the year at CPA while researching the topic of innovation in international telecommunications and multi-national companies. Philippe Amouyal came as a fellow from the French Ministry of Foreign Affairs to study industrial innovation in small businesses. Professor Bertil Hessel of the Institute Universitaire de

Technologie of Paris studied the issues facing declining industries. Professor William Low of the Department of Physics of the Hebrew University, Jerusalem, visited CPA to continue his research into scientific and industrial policy and to write on the topic of innovation.

Marco F. Diani, Attache de Recherche, Centre d'Etudes Sociologiques, and part-time researcher at the Istituto di Psicologia del CNR, Rome, was here twice this past year and will be in residence this coming year. He is working on an international comparison of the impact of new technologies in both new and older industries and participating in preparation of a joint proposal for a study of office automation in the French administration.

Dr. Caroline Whitbeck, formerly Professor of the Philosophy of Medicine, University of Texas Medical Branch, Galveston, developed research papers on the role of values in decisions regarding technology and science. She was recently awarded an NSF Visiting Professorship for Women in Science & Engineering for the coming year to research the role of "values" in decisions regarding technology and science. She will join the teaching teams for two courses at MIT: the Project Proseminar in Technology and Policy, and The Profession of Engineering. Dr. Whitbeck and Dr. Priest are presently in the final stages of negotiation with NSF-NEH (EVIST-STHV Program) regarding a project entitled, "The Identification of Ethical Issues in The Design of Computer Information Systems In Medicine."

NICHOLAS A. ASHFORD

Center for Transportation Studies

The Center for Transportation Studies (CTS) completed its tenth year in 1982/1983. Since its founding in 1973, the Center has worked to stimulate and coordinate research and education in transportation at MIT, and to develop working relationships with the transportation profession. As we enter our second decade, we remain committed to those objectives, through development of an array of methodologies for analyzing transportation problems and by bringing interdisciplinary perspectives to the solutions.

Since its beginning, the Center has conducted nearly $13 million of research involving all transportation modes and covering a diversity of economic and geographic settings. The Masters Program in Transportation, established in 1979, has graduated 56 students and our continuing education programs attract over 100 mid-career professionals each year.

The Center has working relationships with nearly 60 faculty members from 13 departments within the Institute. On-going review and direction is provided by the CTS Executive Committee which included the following members for 1982/83: Professor Ann Friedlaender (Head, Department of Economics), Professor Ralph Gakenheimer (Urban Studies and Planning), Professor Steven Lerman (Head, Transportation Systems Division, Civil Engineering), Professor Thomas Magnanti (Head, Management Sciences Group, Sloan School of Management), Professor Amedeo Odoni (Chairman, Standing Faculty Committee for the Transportation Masters Program; Aeronautics and Astronautics), Professor Harilaos Psaraftis (Ocean Engineering), and Professor David Wormley (Head, Department of Mechanical Engineering).

Master of Science in Transportation Program

During 1982/83, a total of 20 students graduated with the degree of Master of Science in Transportation. This represents the largest group of graduates to date and brings the total to 56.

While the existing Program has proved effective in preparing students for careers in the field, the Standing Faculty Committee undertook a comprehensive review of the curriculum during 1982/83 and as a result adopted a revised set of requirements to be initiated with the class entering in the fall of 1983. The revised program will consist of three major components:

Core subjects	18 units
Program area	36 units
Electives	18 units
Total	72 units

The core is required to ensure a common frame of reference for all students in the program. There are two core subjects of 9 units -- each of which must be taken simultaneously during the student's first (fall) term in the program:

Transportation Systems Analysis
Transportation Economics

The first of these subjects establishes the basic concepts used in the analysis of transportation systems, building upon a traditional strength of the MIT program. The second subject recognizes the need of transportation specialists for a background in economic principles as they apply to the transportation field.

The program area consists of a sequence of four subjects related to a particular track of specialization in transportation. Each student must specify a program area sequence that includes at least one subject which deals with transportation institutional analysis and policy or with transportation operations management. The program areas (each of which may be considered to be a professional interest group with which a student can associate) can have a modal or a disciplinary focus.

Typical program areas include:

Air Transportation
Freight Transportation
Ocean Transportation

Transportation Technology
Urban Transportation
Transportation Systems Analysis
Logistics and Physical Distribution Management
Transportation Policy and Institutional Analysis
Transportation, Land Use and Regional Development
Transportation Economics
Transportation in Developing Countries

In addition to the 72 units of subjects, each student is required to write a Master's thesis. The research associated with the thesis usually requires one to two terms to complete, so students generally will take three to four terms to complete the program.

The new MST program requirements differ from the earlier ones in two significant respects: (1) the core subject on transportation systems analysis has been expanded from 6 to 9 units and the economics subject is now required of all students; (2) the core subject units have been reduced to 18 (from the former 33) and, conversely, the program area has grown to 36 units (or four subjects) from the former 18. These changes have been adopted for the following reasons:

a. To broaden the common base of material on which the program builds. This is accomplished through an increase in the number of common units required of all students from 6 to 18.

b. To give students more opportunity to add depth to their program, accomplished through doubling the number of subject requirements in the program area.

c. To take better advantage of available faculty resources in the various departments and to adjust to changes in the composition and interest of our faculty.

In conjunction with the program revisions, curriculum development has been directed toward three priority areas:

- Development and improvement of core subjects

- Development of more advanced subjects building on the core, principally in the areas of policy, economics, and systems analysis with limited efforts in management and technology

- Development of texts for two core subjects, CTS 120, Transportation Institutional Analysis and Policy, and CTS 150, Transportation Demand and Activity Analysis

This year (1982-1983) curriculum development has been directed specifically to three areas:

a. Further development and improvement of the two newly required core subjects in Transportation Systems Analysis and in Transportation Economics described earlier.

b. Preparation of classroom-oriented software and of meaningful computer-aided exercises for use in subjects covering such computer-based transportation tools as network analysis, scheduling and routing algorithms, mathematical optimization and simulation.

c. Coverage of about 25% of the costs of establishing a Transportation Computer Laboratory.

All three of these undertakings are consistent with the Long Range Plan of CTS. In particular, the second of these initiatives is intended to encourage the use of computer-based planning and decision-support tools in our MST program. While many of our faculty have been in the forefront of research on such tools, it is our feeling that these tools have not yet found their way into our program as forcefully as they should.

Research

The CTS Research Program in 1982/83 totalled more than $1.7 million and included more than 40 projects. (Complete details on the Center's research program are contained in the book titled Research Projects in Transportation 1982/83 which is available upon request.) This year, for the first time, more than 50% of the Center's research funds were obtained from sources other than the U.S. Federal Government. This reflects the results of an effort begun three years ago to broaden the base of research support with particular emphasis upon projects in the private sector.

Toward that end, the Center is fortunate to have an endowment whose earnings are used to support seed research, curriculum development for educational programs, and student fellowships. This endowment, which had a value of more than $1.3 million in June 1983, has been provided by a series of gifts from the

UPS Foundation, whose most recent gift was $250,000 in December of 1982. The earnings from this endowment, in conjunction with membership fees from the CTS Affiliates Program, allow the Center to initiate research and educational efforts which otherwise would be very difficult or impossible to fund, and the UPS fellowships offer a strong attraction for top students in the field.

During 1982/83, the Center's research program in the private sector expanded substantially. Building upon a series of continuing projects in the rail industry we were selected to be the initial institution to be funded under the Association of American Railroads' Affiliated Laboratory Program. The Center's Rail Group was selected to undertake research in economics and systems, both on specific projects and in the field more generally. In the motor carrier industry, projects were continued in the development of methodologies for load planning in less-than-truckload operations and an important new project was begun on vehicle routing between major terminals in metropolitan areas. And as the year came to a close, additional projects in both rail and motor operations were being discussed with the likelihood that they will begin in the next few months.

A new area of research was identified during 1982/83 - logistics and physical distribution - and several efforts in that area were begun. Three seed research projects in the area were funded with funds from the Center's endowment and from its Affiliates Program. These projects are:

Vehicle Routing to Replenish Spatially Distributed Inventories
Professor Richard Larson

Transportation Networks for Shippers
Professor Steven Graves

Development of a Shipper Logistics Model
Professor Yossi Sheffi
Professor George Kocur

These projects are the beginning of an important program in logistics at the Center. It will include seminars and continuing education programs as well as research to be done in cooperation, and with the support of, the distribution function in industrial firms.

CTS Affiliates Program

Two years ago, CTS began an Affiliates Program in which industrial organizations could establish an on-going working relationship with the Center. The principal objectives of this program are (1) to expand both the research and educational relationships between the Center and the private sector, and (2) to provide a continuing source of unrestricted funds to support new research initiatives and other CTS activities. At the end of 1982/83 there were eight members in the program (General Motors, General Mills, IU International, Southern Pacific, Sea-Land, United Parcel Service, IBM and Digital Equipment Corporation).

During 1982/83 several activities were presented for members of the Affiliates Program including a technical seminar in December ("Analytical Methods for Transportation and Logistics Planning") and a senior executive symposium in March which covered several topics in competition, deregulation, and transportation infrastructure. In addition, "company days" were conducted for several members in which representatives of the firm came to MIT and met with selected faculty members to discuss current problems and research possibilities.

Other Activities

The Center's continuing education programs during 1982/83 included the Special Studies Program in Transportation (4 courses) and the Executive Program in Transportation ("Strategic Management in Transportation"). More than 100 participants, principally practicing professionals and executives in the field, attended these courses. Based upon comments from participants, including faculty interests, and advice from the Center's Advisory Committee, the Special Studies Program has expanded to seven courses, and a revised version of the Senior Executive course will be offered in January of 1984.

In addition to its formal research and educational programs, the Center sponsors a Luncheon Seminar Series during the academic year. This series brought a total of 18 industry and academic leaders to MIT during the 1982/83 year. Also, the Center publishes a newsletter and distributes research reports, faculty papers, and student theses in response to requests. The Center, in conjunction with the MIT Press, has a continuing effort underway to publish a series of textbooks for transportation. To date, a total of eight books have been published in this series. Finally, members of the Center's research and administrative staff contributed papers and participated in several professional meetings.

DANIEL ROOS

Electric Power Systems Engineering Laboratory

The Electric Power Systems Engineering Laboratory (EPSEL) supports and encourages research and education in the varied disciplines which together constitute the field of electric and electromechanical energy conversion and control. During the past year nine faculty members, five research staff members, and approximately 40 graduate and undergraduate students were engaged in research in the laboratory.

The major research project in the Laboratory continues to be the design and construction of a 10-MVA superconducting generator using advanced and previously untested concepts. Power electronics research continues to grow, reflecting advances in semiconductor device technology and new application areas. The MIT-Industry Collegium in Power Electronics completed its first successful year utilizing the MIT developed Parity Simulator. Research in electromechanical energy conversion systems has resulted in an innovative and significant technique for stabilizing magnetically levitated energy storage flywheels. Microprocessors are being used extensively in the control of energy systems, and almost every research project in the Laboratory is using these devices. In recognition of the increasingly important role of the microprocessor in energy systems, a new and very successful laboratory subject, Microprocessor Control of Energy Systems, is now being offered in the Laboratory.

During the past year the Laboratory has undertaken several new initiatives. The role and requirements of electromechanical systems in robotics is continuing to be evaluated. Research in the general area of intelligent control of energy, i.e., exploiting new components for communication and computation, has been initiated. Research has also been initiated in development of an integrated machine combining microprocessor control with mechanical and electrical systems.

During the year a new Laboratory Advisory Board was assembled both to review ongoing research and assist in structuring future MIT-industry cooperation.

Throughout the year a seminar series was held jointly with the High Voltage Research Laboratory (HVRL) and the Continuum Electromechanics Laboratory (CEL) which drew attendees from across the Institute.

In the late spring a decision was made to combine HVRL, CEL and EPSEL. This new laboratory, the Laboratory for Electromagnetic and Electronic Systems begins operation July 1, 1983.

THOMAS H. LEE

Innovation Center

Student involvement in the Innovation Center increased during the past year, with approximately 100 students participating in classroom, laboratory and other activities. The industrial innovation program is providing many excellent opportunities for students to be a part of authentic innovation experience, fulfilling of the major educational objectives of the Center.

During the latter half of the year, the upturn of the economy has increased the level of interest in the Industry/Innovation Center Cooperative Program, providing an excellent opportunity for the program to reach a stable size before the National Science Foundation seed money is depleted. This program of product creation and development, in its second full year of operation, has demonstrated the feasibility of this type of linkage between a university program and member companies. The uniqueness of the program involves R & D which focuses on the marketplace, meeting the new product needs of member companies, while enhancing the educational experience of engineering students through realistic new product creation and development work.

A new graduate engineering subject, The Idea/Product Transformation, is being developed under a curriculum development grant from the Dean of Engineering. This new subject on product design and development provides a complementary subject offering between the two existing graduate subjects offered by the Center: Invention and Entrepreneurship. These three subjects cover the broad spectrum of information relating to the technological innovation process, from need recognition to the establishment of a mature market for a new product.

The importance of innovation education is being recognized throughout the United States and around the world. On a regular basis, the Center is providing written materials and other assistance to groups from universities, governments, and private organizations who are in the process of establishing Innovation Center activities. The Center recognizes this as an important contribution, and this type of interaction has increased during the past year.

DAVID G. JANSSON

Laboratory for Computer Science

The MIT Laboratory for Computer Science is an interdepartmental laboratory whose principal goal is research in computer science and engineering.

Founded in 1963 as Project MAC (for Multiple Access Computer and Machine Aided Cognition), the Laboratory developed the Compatible Time-Sharing System (CTSS), one of the first time-shared systems in the world, and Multics -- an improved time-shared system that introduced several new concepts. These two major developments stimulated research activities in the application of on-line computing to such diverse disciplines as engineering, architecture, mathematics, biology, medicine, library science, and management. Since that time, the Laboratory's objectives expanded, leading to research across a broad front of activities that now span four principal areas.

The first such area entitled Knowledge Based Systems, involves making programs more intelligent by capturing, representing, and using knowledge which is specific to the problem domain. Examples are the use of expert medical knowledge for assistance in diagnosis carried out by the Clinical Decision Making Group; the use of solid-state circuit design knowledge for an expert VLSI (very large scale integration) design system by the Real Time Systems Group; and the use of specific knowledge about budgets for an expert budget planning system by the Programming Technology Group.

Research in the second and largest area entitled Machines, Languages, and Systems, strives to discover and understand computing systems at both the hardware and software levels that open new application areas and/or effect sizable improvements in their ease of utilization and cost effectiveness. For example, the Programming Methodology Group and the Real Time Systems Group are developing languages and operating systems for use in large (thousands of computers) geographically distributed systems. The networks for such distributed environments are studied by the Computer Systems and Communications Group, while distributed file servers and cryptographic protection techniques are pursued by the Computer Systems Structure Group. New research in this overall area also includes the architecture of very large multiprocessor machines (dedicated to a single task, e.g., speech understanding or machine vision) by the Computation Structures, Functional Languages and Architectures, and Real Time Systems Research Groups.

The Laboratory's third principal area of research entitled Theory, involves exploration and development of theoretical foundations in computer science. For example, the Theory of Computation Group strives to understand ultimate limits in space and time associated with various classes of algorithms; the semantics of programming languages from both analytical and synthetic viewpoints; the logic of programs; and the links between mathematics and the privacy/authentication of computer-to-computer messages. Another example of work in this area involves the study of distributed systems by the Theory of Distributed Systems Research Group.

The fourth area of research entitled Computers and People, entails societal as well as technical aspects of the interrelationships between people and machines. Examples include the use of computers in the educational process by the Educational Computing Group; office automation research carried out by the similarly named Laboratory group; the use of interconnected computers for planning; as well as the sociological impact of computers on individuals; and the ethical problems of distributed responsibility posed by multiprogrammer systems carried out by the Societal Implications Research Group.

During 1982-1983, the Laboratory embarked on the ambitious project of constructing an emulation facility consisting of 64 interconnected large computers, whose purpose is to analyze the behavior of larger (up to several thousand machines) multiprocessor systems. This facility will enable experimenters at MIT and elsewhere in the United States to try out their ideas before committing their proposed architectures into silicon circuits. Another important development during this period has been the development of CONCERT by Professor Robert Halstead of the Real Time Systems Group. It consists of a prototype four-processor multiprocessor system that will eventually interconnect 32 processors. Together with a parallel version of LISP, this system will be used primarily to explore the use of multiprocessor systems in graphics and other applications.

Another growth activity during 1982-83 has been the newly established Educational Computing Group which is headed by Professor Harold Abelson and includes Professor Seymour Papert and Drs. Andrea diSessa and Sylvia Weir. This group, which in the last 12 years developed the widely used language LOGO, is currently focusing its efforts on the use of computer technology, cognitive science, and educational innovation, primarily at the secondary school level.

During this reporting period we have also made substantial progress in distributed systems research. This major Laboratory focus continues to occupy the attention of about half of our people. Our recent results have put us in a position to construct a class of geographically distributed and interconnected systems which strive to balance local autonomy with application cohesiveness. The hardware resources that we designed have been transferred to industry (Texas Instruments) and we expect to take delivery of 30 commercial-level advanced personal computers before the end of 1983. These and other related machines (single-user Vaxes and Lisp Machines) are being interconnected into prototype distributed systems within the Laboratory. It is through these prototypes that we are implementing the collection of research results that we have acquired up to now. In particular, we are experimenting with languages, operating systems and applications that establish the feasibility of distributed systems. This feasibility, in turn, means that an aggregate of arbitrarily many such interconnected and decentralized machines can render at minimum all the functions of a single centralized computer environment -- in the presence of local failures which are likely to be frequent as the number of participating machines becomes large.

Two new research groups were formed during 1982-83: The Imaginative Systems Group, headed by Professor David Gifford, is involved in the development of a community information system which uses the MIT FM station to broadcast the New York Times and other communal data to machines in several researcher's homes. At these sites, special programs "filter out" and collect automatically the data of interest to each system's owner. The Theory of Distributed Systems Group, headed by Professor Nancy Lynch, is involved in the theoretical study of distributed systems. Other group changes carried out at the end of this reporting period involved the phasing out of two groups, Office Automation and Computer Systems Structure, because of the departure of their respective leaders.

Other significant events in 1982-83 were the supply by IBM of 40 Personal Computers to our faculty and senior researchers for familiarization purposes, and of an IBM 4341 machine for use as a simulator in our emulation facility. In addition, several members of the Laboratory worked toward Project Athena, MIT's major educational computer project that entails some $50 million of grants by Digital Equipment Corporation and IBM.

During the past year we were joined by Assistant Professor David Gifford, Assistant Professor F. Thomas Leighton (jointly with the Mathematics Department), Associate Professor Nancy Lynch, and Research Associate Dr. William Long. Our Laboratory consisted of 348 members -- 48 faculty and academic research staff, 30 visitors and visiting faculty, 70 professional and support staff, 100 graduate and 100 undergraduate students -- organized into 17 research groups. The academic affiliation of most of these faculty and students is with the Department of Electrical Engineering and Computer Science. Other academic units represented in the Laboratory are Mathematics, Architecture, Humanities, Center for Policy Alternatives, Sloan School of Management, and the Research Laboratory for Electronics. Laboratory research during 1982-83 was funded by 17 governmental and industrial organizations, of which the Defense Advanced Research Projects Agency of the Department of Defense provided over half of the total research funds.

Technical results of our research in 1982-83 were disseminated through publications in technical literature, through Technical Reports (TR278-TR299), and through Technical Memoranda (TM221-TM288).

MICHAEL L. DERTOUZOS

Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems (LIDS) is an interdepartmental research laboratory with the primary function of conducting research in systems, communications, and control. Fundamental theoretical issues and important application areas are among its studies. Computers and computation play a vital role in this research.

The Laboratory was founded in 1939 and played a major role in the development of servomechanisms during World War II and the post-World War II period. Its name was changed from Servomechanisms Laboratory to Electronic Systems Laboratory (ESL) in 1959. Until March 1, 1978, ESL was a departmental laboratory in the Department of Electrical Engineering and Computer Science. On March 1, 1978, ESL was designated as an interdepartmental laboratory reporting to the Office of the Provost. On September 20, 1978, its name was changed to Laboratory for Information and Decision Systems to reflect more accurately the research interests of its faculty, full-time research staff, and students.

As an interdepartmental laboratory, LIDS now reports to the Dean of the School of Engineering, Professor Gerald L. Wilson. The director of the laboratory is Sanjoy K. Mitter, professor of Electrical Engineering. Robert G. Gallager, professor of Electrical Engineering, is the associate director. The assistant director is Stanley B. Gershwin, principal research scientist.

Thirteen faculty members and seven research staff members are associated with the laboratory. In addition, approximately 60 graduate students conduct research in LIDS. Currently, the laboratory provides 35 research assistantships to graduate students. A number of undergraduate students also participate in research and thesis activities.

Research support has been provided by the American Newspaper Publishers Association, the National Aeronautics and Space Administration, the Defense Advanced Research Projects Agency, the Department of Transportation, the Gannett Foundation, the Office of Naval Research, the Army Research Office, the Department of Energy, the National Science Foundation, the Air Force Office of Scientific Research, the Library of Congress, the National Library of Medicine, the General Accounting Office, the General Electric Company, the DuPont Company, and the IBM Corporation.

RESEARCH

The current research activities of the Laboratory cover a wide range of theoretical and application areas. The common theme is the critical role played by systems, communications, and control.

Communication Science and Systems

Research in communication science and systems ranges from studies of the underlying theoretical information properties of networks and point to point systems, to architectural design. A major research program in this area deals with reliable, efficient communication in data networks. Some of the topics in this program are routing, flow control, the communication complexity of distributed algorithms, contention resolution in broadcast networks, protocols, failure recovery, and topological design. Professor Gallager and Professors Dimitri Bertsekas, Pierre Humblet, and their students are conducting this research.

Command, Control, and Communications (C^3) Systems

The study of military C^3 systems defines basic research directions in the areas of distributed detection and estimation, distributed databases, and team decision theory. Professors Michael Athans and Robert R. Tenney, Dr. Alexander H. Levis, and Elizabeth R. Ducot, together with a large group of graduate students, are developing novel theoretical and algorithmic approaches for this rich class of system-theoretic problems. Recent advances have been made in the following areas: a) organization structures based upon information-theoretic concepts, b) mathematical models of distributed decision problems with limited communications, c) multisensor/multi-object tracking algorithms including sensor scheduling, d) integration of distributed database systems within vulnerable communication networks, and e) development of a computer-based testbed in support of the analytical research.

Theory and Algorithms for Optimization

This project focuses on analytical and computational methods for solving broad classes of optimization problems arising in engineering, operations research, applications in communication networks, control theory, power systems, computer-aided manufacturing, and other areas. In addition to traditional subjects in nonlinear and dynamic programming, there is currently an emphasis on solving large-scale problems involving network flows and differential and difference equations dynamics. The thrust there is two-fold: first, to find ways to handle the typically huge number of constraints; and second, to explore the use of distributed and parallel processing in order to reduce the computation time needed to solve a problem and economize on information transfer from remote data collection points to a computation center. This gives rise to fundamental issues involving the synchronization of computation and communication that are as yet only partially resolved. This work is performed by Professor Bertsekas and his students.

Stochastic Systems and Signal Processing

A variety of stochastic estimation, analysis and signal processing problems are being studied by Professors Alan S. Willsky, Bernard C. Levy, Professor Mitter, and their students. Theoretical studies are being undertaken in the areas of estimation algorithms, i.e., mapping methods, for spatially distributed random processes, nonlinear filtering, relationships among filtering problems and problems in scattering theory, and the analysis of large-scale systems subject to a variety of very rare events. Complementing this theoretical research are a variety of more applied projects including the design of algorithms for detecting and compensating for sensor or actuator failures, and the development of model-based signal processing algorithms. The specific signal processing problems include the diagnosis of arrhythmias in electrocardiograms, the detection of objects or anomalies given tomographic measurements (such as those made using X-rays or ultrasound) in medical and industrial nondestructive testing applications, and the analysis and inversion of spatially distributed geophysical data.

Multivariable and Adaptive Control

Systematic design of multiple-input/output systems, using a unified time- and frequency-domain framework, is an extremely active research area in the Laboratory. Various theoretical and application studies are carried out by Professors Athans and Levy, Professor Gunter Stein, Dr. Lena Valavani, and their students. Theoretical research deals with issues of robustness, aggregation, and adaptive control. Recent application-oriented studies include the control of Vertical Takeoff and Landing aircraft, turbofan control system designs, and issues of integrated flight control. Recent results in adaptive control indicate that most available adaptive control algorithms can become unstable in practical situations.

Nonlinear Systems

Research in the area of deterministic nonlinear systems focuses on three separate aspects: analysis, including modeling of nonlinear systems and circuits, numerical methods for their simulation including singular pertrubation and multiple time scale methods; stability, including the study of static and dynamic bifurcations, complex dynamics, and chaotic behavior; and methodologies for nonlinear control--especially geometric, sliding mode, or switched and adaptive control systems. Also under study is the qualitative behavior of stochastic nonlinear systems including bifurcations in the presence of small noise as well as nonlinear filtering and estimation of Markov processes from noisy observations. The connections between the nonlinear filtering, stochastic control, and mathematical physics are being investigated. This study is being conducted by Professor Mitter and his students.

Numerical Linear Algebra and Parallel Computing

Recent technological innovations in microprocessor technology, particularly the standard for floating point arithmetic and replicating functional microprocessor units proposed by the Institute of Electrical and Electronics Engineers, enhance the research and design of numerical algorithms for parallel tasking. The programming language, Ada, permits the expression of such algorithms in a recognized high-level language. Research on algorithmic design, partitioning of data, and the failure of algorithms due to sensitivity perturbations of data constitute the main themes of our research (which can have applications in many areas not limited to control and communication). An important ingredient of this research is the construction of an appropriate numerical algorithm in a parallel tasking environment. Ms. Virginia Klema and Ms. Ducot are responsible for this research at LIDS. Professors Steve Ward and Richard Zippel from the MIT Laboratory for Computer Science also participate in this work.

Manufacturing Systems

Modeling, analysis, optimization, and control of manufacturing systems are studied by Dr. Gerswhin, Dr. Akella, and their students. The effects of machine failures on routing and scheduling policies are investigated in order to reduce in-process inventories and to reduce the time spent by material in the factory. The architecture of an on-line computer system which will optimally control the flow of material is being considered. The concept of a transfer (or production) line has been extended to that of an assembly/disassembly network for the purpose of studying the interplay between reliability, speed, buffer size, production rate, and average in-process inventory levels. The FlexMan computer system is being developed by Ms. Ducot to help transfer our results to industrial users.

Information Transfer and Retrieval

Research in information and retrieval focuses on investigations of issues concerning how computer-based information systems can be engaged more easily and effectively by potential human users and how digital techniques can be employed to move information electronically between nodes of a network. These investigations involve the application of theoretical, analytical, and experimental techniques in areas such as information and computer science and technology, computational linguistics, and psychological human-factor studies.

Three current projects include analytical and experimental investigations of a) electronic document-delivery networks applicable to interlibrary resource-sharing; b) expert computerized intermediary systems to assist end-users in accessing and operating heterogeneous bibliographic databases and retrieval systems; and c) intelligent terminals with microprocessor and telecommunications hardware and software that enable automatic connection and log-in to remote computers. Staff members directing these three efforts are, respectively, Professor J. Francis Reintjes, Richard S. Marcus, and John E. Ward.

Reliability Analysis

Working with Vicki Bier, Professor Alvin Drake has completed a study on "uncertainty importance," a measure characterizing the dependence of the variance of a system failure probability on the uncertainties associated with estimates of individual component failure probabilities. Several qualitative aspects of the measure have been established, both for independent and for types of dependent component failure probabilities. Using the MACSYMA symbolic computer language, a program has been developed and applied to several examples, including one from the WASH-1400 Reactor Safety Study.

PERSONNEL

Professor Sastry, who was an Assistant Professor in the Department of Electrical Engineering and Computer Science and a member of the Laboratory, left in January 1983 to join the faculty of the University of California, Berkeley.

Professor Vidyasagar of the University of Waterloo was a Visiting Professor in the Department of Electrical Engineering and Computer Science and a member of the Laboratory during the Spring Semester of 1983.

SANJOY K. MITTER

Laboratory for Manufacturing and Productivity

One of the major goals of the Laboratory for Manufacturing and Productivity (LMP) is to establish the scientific base for the field of manufacturing and thus the discipline of manufacturing engineering. In order to achieve this goal, the Laboratory emphasizes the axiomatic approach to design and manufacturing; establishes research programs that may have long term impact on both education and industry; and creates research ideas and solutions which can remove the basic constraints that limit the rational growth of the industrialized world. As a result of this effort, new concepts and methodologies have been developed, and many new processes that yield unique materials have been innovated.

In order to address the diverse issues involved in manufacturing, the Laboratory has systematically expanded its fields of research and strengthened the underlying disciplinary activities. The most recent addition to the Laboratory's research and teaching activities is a group of five faculty members and 20 graduate students which is involved in industrial robotics. This research group complements the efforts of such other existing research groups as metal processing, polymer processing, machine dynamics and intelligent machines. The Laboratory, with over 70 graduate students, 25 faculty and research staff and 25 supportive staff, is now the largest organization of its kind among the American universities.

In addition to executing 70 research projects, the faculty members of the Laboratory have been involved in educational programs for manufacturing engineering in collaboration with colleagues from other schools, departments and laboratories. There will now be seven graduate level subjects related to manufacturing. A new undergraduate textbook is being developed by nine members of the Laboratory under the leadership of Professors Nathan H. Cook and Nam P. Suh. A new microcomputer Laboratory is also being established to consolidate the teaching activities of computer-aided manufacturing.

The Laboratory's research programs have produced a variety of interesting and significant results. An ultra-tough plastic has been made that does not fracture even at liquid nitrogen temperature; the mix-alloying process shows the promise of being an important development in making high-strength, creep-resistant, tough metals; new tribological surfaces that do not change the electric contact resistance even after prolonged sliding actions are being developed, as is an intelligent metal-forming machine which shapes metals with only geometric inputs.

Since more than 65 percent of its research funding comes from industry, the Laboratory is seriously concerned about technology transfer to industry. The prerequisites of the technology transfer process, i.e., the synergistic relationship among the donor, the acceptor and the transfer agent, is often missing in many university/industry interactions. In order to remedy this situation, the LMP Collegium is now actively soliciting industrial members who are interested in having direct access to the LMP's research results. In addition, an Industrial Liaison Office (ILO) symposium on "The Future of the Factory" was held to disseminate the information. In addition to assisting industrial sponsors assimilate the research results generated in MIT, the Laboratory transferred some of its new techniques to two small business firms. The 1983 Ralph E. Cross Lecturers in manufacturing sciences were Professor Øyvind Bjørke of the Norwegian Institute of Technology and Mr. Philippe Villers of Automatix, Inc., who gave lectures on computer-aided manufacturing and robotics, respectively.

The Laboratory has been fortunate to have strong support of its programs and goals. Mr. Ralph E. Cross has made a major gift to MIT to support the Laboratory's activities. The International Paper Company Foundation provided a fellowship to support minority and female students and the American Can Company Foundation is still supporting a junior faculty chair in manufacturing. Many industrial leaders of sponsoring firms have provided more than their share of leadership in making the LMP a viable place to educate students, to generate new ideas, and to transform ideas into useful tools for mankind.

Materials Processing Center

Materials processing is the engineering field that seeks to control the shape, structure, and properties of materials, doing so with acceptable economic and social costs. It links basic science to societal needs and experience. Materials processing includes extraction, processing into bulk and/or engineering materials, fabrication, recycling, and disposal.

The Materials Processing Center (MPC) was created to provide a much needed interdisciplinary forum for research and education in materials processing. The Center's aim is to strengthen the link between research in the university and innovation in industry. Center activities encompass all engineering materials including metals, ceramics, polymers, electronic materials, composites, superconductors, and thin films.

The total annual funding of the activities of the Center, now in its fourth year of operation, has grown to more than $3 million, which includes industrial support in excess of $2 million. Strong support is also provided by government agencies; in particular, the National Aeronautics and Space Administration. Major research programs are under way in the following areas: rapid solidification processing, ceramic processing and engineering, materials systems, welding, semiconductor processing, electronic materials, chemical metallurgy, non-destructive evaluation, polymer processing, electroprocessing, mathematical and physical modeling, corrosion, mechanical properties, solidification processing, composites, and computer-aided processing. Research efforts in these areas over the past year will be outlined in the MPC's annual report.

In September of last year, Professor H. Kent Bowen replaced Professor Merton C. Flemings as Director of the MPC. He then appointed three new Associate Directors: Professor Frederick J. McGarry, Professor Julian Szekely, and Professor August F. Witt from the research areas of polymers, metals, and electronic materials, respectively. The Associate Directors provide a liaison between the interests of their particular research area and the Center.

During 1982, the Industry Collegium, created in 1981, expanded to include more than 50 companies. The central goal of this Collegium is to provide a mechanism for improved interaction of Center faculty, staff, and students with industry personnel; it operates in close cooperation with MIT's Industrial Liaison Program. Membership fees provide funds for fellowships and scholarships in materials processing and seed research projects.

Two Collegium workshops were held in the past fiscal year. The specific aim of these workshops is to provide a forum for faculty, staff, students, and industry representatives to exchange ideas, identify innovative research opportunities, and arrange cooperative or sponsored research and development programs. One workshop was held on October 6-7, 1982 and was entitled "Mathematical and Physical Modeling of Materials Processes." The other, held March 23-24, 1983, was on "Ceramics Powder Processing: Is There a Better Way?" Both workshops were highly successful, with over 80 participants from industry, government, and academia for the first and over 150 participants for the second. Another workshop, this time on "Welding and Joining Processes," is planned for Fall of this year.

In the past year, the Center, as part of its effort to expand the talent base in the field of materials processing, initiated Summer Scholarship and Graduate Fellowship Programs, as well as an intensive Summer Course, in conjunction with IBM personnel, for IBM employees. (This course will become available to other companies in the fall). The Center also plans to develop a means of providing white papers to industry and government on critical materials issues. The goal of this effort is to provide an overall systems perspective on the potential commercial and/or strategic implications and impact of on-going materials processing research activities.

H. KENT BOWEN

School of Humanities and Social Science

The year was notable for the first substantial change in the structure of the School of Humanities and Social Science for many years. At the beginning of the academic year the Department of Humanities ceased to function as an operating unit. The six sections and programs that constitute the Department -- Anthropology/Archaeology, Foreign Languages and Literatures, History, Literature, Music, and Writing -- became autonomous. The headship of the Department was abolished and the headquarters were closed. Each section and program thus acquired de facto the characteristics of a department, and their heads became members of the School Council and the Faculty Council.

The change at first sent shock waves in every direction. Section and program heads needed a crash course to introduce them to the way in which departmental business is done. Secretaries found themselves handling a range of problems that were new to them. The Dean's Office had perforce to take over the departmental accounts, had to oversee the changes that were taking place in building 14, and answer a myriad of questions. Once the novelty of the situation wore off, and the sections had been supplied with word processors to help lighten the burden of typing and record keeping, the new arrangements turned out to be working very well. The School Council, now nearly doubled in size, became once more the fast-moving, witty, and intellectually stimulating body it had been before. The sections and programs found their feet and began to function with a renewed sense of assurance. Even the Dean's Office quieted down. By the end of the year, section and program heads, secretaries, and those of us in the Dean's Office all felt that it had been on balance a good year.

This year was also notable for the first change in the Institute Humanities, Arts, and Social Sciences requirement since 1974. The change was engineered with great skill by Professor Sylvain Bromberger, my representative on the Committee on Educational Policy, and won general approval. Much of the change was concerned with mechanics, but there was also a significant redefinition of the criteria for Humanities Distribution subjects. One consequence of the change is that the Dean of the School of Humanities and Social Science has been given responsibility for monitoring the working of the requirement. In anticipation of the change, I had already arranged to transfer the work with undergraduates hitherto done in my office to an enlarged Humanities Undergraduate Office, which in July had become a School office reporting to me. This office, under Professor Travis Merritt, is now responsible for handling all business connected with the Institute Humanities, Arts, and Social Sciences requirement, undergraduate cross-registration with Harvard, and with the administration of Course XXI. The Dean's Office will hereforth be chiefly concerned with the much enlarged administrative role that it has acquired as a result of the changes in the structure of the School. In recognition of this changed role, Ms. Janet Romaine, who had hitherto divided her time between work with students and administration, was appointed Assistant Dean for Administration.

For the doctoral programs in the School, this year was notable for the publication of the first survey of such programs in many years, sponsored by the Conference Board of Associated Research Councils. There is always a subjective element in such assessments that makes their results less than a foregone conclusion. As it turned out, most of the ratings confirmed our own expectations. Economics had pulled well ahead of the pack. Philosophy and Political Science had made significant gains, in spite of their relatively small size compared with that of most graduate departments. The surprise was that Psychology dropped out of sight in the rankings. It has never had the size or range of the big graduate programs in Psychology and has never offered teaching in all branches of the field, but in its own branches of the Brain Sciences it has always been one of the acknowledged leaders. Clearly we must think of redesignating the department with a more suitable name and we must pay more attention to marketing what is clearly a top-rate program.

As the year ends, Professor Peter H. Smith, who has been Associate Dean for a comparatively short period, returns to teaching in the Political Science Department. His scholarly career has never been interrupted by administration; he continues extremely active in the Latin American Studies Association and has this year published a new book.

HAROLD J. HANHAM

TABLE I

Enrollment in MIT Distribution Subjects: 1982-83

Field	# of Subjects	Year 1	Year 2	Year 3	Year 4 & 5	Graduate	Total MIT	Harvard	Wellesley	GRAND TOTAL	%
Economics	1	2	1	4	11	1	19	0	1	20	0.5
History of Art and Architecture	5	23	25	38	37	22	145	10	0	155	3.5
Humanities:											
American Studies	1	0	1	3	2	1	7	0	1	8	0.2
Anthropology/ Archaeology	9	54	31	26	28	1	140	0	2	142	3.2
Foreign Languages	10	169	117	115	68	19	488	1	3	492	11.1
History	18	169	115	96	92	2	474	2	5	481	10.8
Literature A (English)	16	291	156	126	130	3	706	0	4	710	16.0
Literature B (Foreign Language)	8	23	27	20	17	2	89	0	4	93	2.1
Music	7	134	128	94	72	1	429	0	4	433	9.7
Western Tradition	5	67	71	60	50	0	248	1	0	249	5.6
Writing	4	149	73	50	43	1	316	0	0	316	7.1
Labor in Industrial Society	1	9	0	7	13	0	29	0	0	29	0.7
Linguistics	1	14	34	26	26	0	100	0	0	100	2.2
Philosophy	6	253	127	97	71	3	551	0	3	554	12.5
Political Science	14	100	77	94	44	1	316	1	13	330	7.4
Science, Technology, and Society	7	53	31	30	36	2	152	3	0	155	3.5
Urban Studies	4	21	24	22	24	2	93	2	2	97	2.1
Visual Arts	2	23	22	19	18	0	82	0	2	84	1.9
TOTAL	119	1554	1060	927	782	61	4384	20	44	4448	100.1

Enrollment data are taken from the Registrar's fifth week report.

TABLE II

Enrollment in Humanities, Arts and Social Sciences Elective Subjects: 1982-83

Field	# of Subjects	Year 1	Year 2	Year 3	Year 4 & 5	Graduate	Total MIT	Harvard	Wellesley	GRAND TOTAL	%
Economics	14	258	414	308	281	41	1302	4	10	1316	23.1
Dance & Theater Arts	3	8	10	9	7	0	34	0	0	34	0.6
History of Art and Architecture	2	1	8	15	28	24	76	1	7	84	1.4
Humanities:											
Anthropology/ Archaeology	14	9	25	29	43	4	110	0	5	115	2.0
Foreign Languages and Literatures	39	270	225	183	150	227	1055	2	29	1086	19.1
History	22	19	50	80	80	3	232	0	9	241	4.2
Interdisciplinary	3	8	16	23	32	4	83	0	7	90	1.6
Literature	21	25	57	91	105	3	281	0	2	283	5.0
Music	11	51	93	110	93	10	357	0	1	358	6.3
Writing	16	89	73	120	181	18	481	1	6	488	8.6
Linguistics and and Philosphy	15	12	56	63	87	10	228	3	2	233	4.1
Political Science	27	18	49	106	111	7	291	6	47	344	6.0
Psychology	11	48	105	148	145	7	453	2	20	475	8.3
Science, Technology, and Society	16	9	18	41	50	8	126	10	13	149	2.6
Urban Studies	7	0	15	16	31	1	63	3	6	72	1.3
Visual Arts	16	10	60	78	102	52	302	3	21	326	5.7
TOTAL	237	835	1274	1420	1526	419	5474	35	185	5694	99.9%

The figures include all subjects listed in the Catalogue as routinely eligible toward the Institute Requirement, and in which students actually enrolled. Other subjects approved by petition have not been counted. Data are taken from the Registrar's fifth week report.

TABLE III

Fields of Concentration Selected in 1982-83
Under the Humanities, Arts, and Social Science Requirement

Field	Year 4 & 5	Year 3	Year 2	Year 1	TOTAL
American Studies	10	3	3	0	16
Ancient & Medieval Studies	13	2	0	0	15
Anthropology/Archaeology	10	3	0	0	13
Drama	12	2	2	0	16
Economics	153	85	20	0	258
Foreign Languages & Literatures	150	121	32	10	313
History	46	39	9	0	94
History of Art & Architecture	8	1	0	0	9
Labor in Industrial Society	0	0	0	0	0
Linguistics	5	3	0	0	8
Literature	75	26	5	1	107
Music	105	45	21	2	173
Philosophy	33	23	3	0	59
Political Science	68	29	5	0	102
Psychology	48	16	6	0	70
Russian Studies	1	1	2	0	4
Science, Technology & Society	16	10	3	0	29
Urban Studies	9	3	6	0	18
Visual Arts & Design	18	14	0	0	32
Western Tradition	4	3	0	0	7
Women's Studies	1	1	0	0	2
Writing	52	33	12	0	97
Special Concentrations	11	6	3	0	20

* Figures not obtainable.

TABLE IV

Undergraduate Majors in the School of Humanities and Social Science*

Year	Economics	Humanities	Philosophy	Political Science	Psychology**	TOTAL
1971-72	63	124	13	38	--	238
1972-73	64	92	15	39	--	210
1973-74	55	67	10	30	--	162
1974-75	63	48	1	14	--	126
1975-76	67	41	3	24	--	135
1976-77	67	31	7	25	--	130
1977-78	52	34	7	21	--	114
1978-79	48	38	5	30	--	121
1979-80	44	37	9	36	--	126
1980-81	50	40	11	30	--	131
1981-82	51	49	9	32	--	141
1982-83	48	37	7	28	11	131

* As registered in the second term of academic year 1971-72 to 1982-83. Data taken from the Registrar's fifth-week report.

** Undergraduate degree in Cognitive Science, instituted in 1982-83.

TABLE V

Graduate Students in the School of Humanities and Social Science**

Year	Economics	Linguistics	Philosophy	Political Science	Psychology	TOTAL
1971-72	104	40	29	70	29	272
1972-73	109	34	24	82	23	272
1973-74	114	33	21	96	25	289
1974-75	114	35	18	95	25	287
1975-76	120	33	16	89	27	285
1976-77	114	32	14	91	29	280
1977-78	123	--	45***	102	24	294
1978-79	121	--	48***	96	28	293
1979-80	138	--	63***	143	36	380
1980-81	126	--	66***	121	32	345
1981-82	111	32+	23+	142	26	334
1982-83	136	31+	20+	163	27	377

** As registered in the second term of academic year 1971-72 to 1982-83 (including special graduate students). Data taken from the Registrar's fifth-week report.

*** Includes students in linguistics.

+ Includes resident graduate students only.

Department of Economics

Graduate fellowship support continues to be the most pressing problem facing the Economics Department. This year the National Science Foundation Fellowships in Economics were reduced by over one quarter with a concomitant reduction in NSF fellows choosing to come to MIT. Since the Department lacked the resources to make a sufficient number of scholarship or fellowship offers to fill the NSF shortfall, it lost a substantial number of able students who received fellowship support from competing institutions. Thus the entering class of graduate students this year is significantly smaller than that of past years, with a somewhat higher proportion of foreign students. In view of the continued dependence of the Economics Department upon the NSF fellowships for graduate student support and the uncertainties associated with their funding, the need for a stable funding source for its graduate students is apparent. Fortunately the Department is embarking on a major fund-raising effort to provide fellowship support, which should alleviate many of these problems.

Happily the other major problems - computing resources and space - that have plagued the Department in recent years have largely been resolved. The installation of the PRIME 850 in the East Campus Computer Facility has substantially increased the computing resources available to the Economics Department and enabled faculty and students to increase their computer usage at considerably reduced costs. The Sloan Building is scheduled to be renovated this coming academic year, and by next summer, the faculty and graduate students of the Economics Department should all be housed on the second and third floors of the Sloan Building. This will provide a welcome change from the previous situation in which the students were housed in E38 and a substantial number of the faculty were removed from their colleagues.

The faculty continue to be highly productive and to work in a diverse number of areas: macroeconomics and policy, i.e., inflation, indexing, and taxation (Professors Stanley Fischer and Rudiger Dornbusch), labor markets and unemployment (Professors Peter A. Diamond and Robert M. Solow), fiscal and monetary mechanisms (Professors Franco Modigliani and Paul A. Samuelson), and financial crises (Professors Samuelson and Solow); international economics, i.e., international financial systems and institutions (Professors Dornbusch and Richard S. Eckaus) and inflation, terms of trade, and growth (Professor Lance Taylor); the structure of labor markets, i.e., segmentation (Professor Michael J. Piore), union status and representation (Professor Henry S. Farber) and labor supply and taxation (Professor Jerry A. Hausman); energy, i.e., industry structure (Professor Morris A. Adelman), energy policy in developing countries (Professor Eckaus), residential and automotive energy demand (Professors Daniel L. McFadden and William C. Wheaton), and regulation (Professor Paul L. Joskow); health economics (Professors Jeffrey E. Harris, Peter Temin and McFadden); theoretical and empirical analyses of industrial organization and market structure (Professors Eric S. Maskin, Garth Saloner, Joseph v. R. Farrell and Franklin M. Fisher); and theoretical analyses of equilibrium properties of economies (Professors Fisher and Timothy J. Kehoe).

A number of honors and awards were received by the faculty this year. Professor Modigliani continued as Vice President of the International Economic Association and Professor McFadden was elected Vice President of the Econometric Society. Professor Jerome Rothenberg continued as national chairman of the Committee on Urban Public Economics. Professor Solow received the Seidman Award in Political Economy, Professor Samuelson received the Alumni Medal of the University of Chicago, and Professor Adelman received an award from the International Association of Energy Economists for contributions to the field. Endowed lectures were given by a number of the faculty: Professor Modigliani gave the Marshall Lectures at Cambridge University; Professor Hausman gave the Fisher-Schultz lecture of the Econometric Society; and Professor Joskow gave the inaugural Joel Dean Lecture at Oberlin. Professors Maskin and Diamond respectively received Sloan and Guggenheim Fellowships. Professor Solow received the Best Teacher award of the Economics Department and an honorary degree from Tulane University.

There were a number of personnel changes this year. Professor Diamond was on leave at Harvard for the year, while Professor E. Cary Brown was on leave for the spring semester as a visiting fellow at the Hoover Institution at Stanford. Professor Paul R. Krugman was on leave for the year as a member of the senior staff of the Council of Economic Advisors in Washington. Two faculty members resigned this year: Professor Marilyn J. Simon, in order to join the Justice Department in Washington; and Professor Lawrence H. Summers, to go to Harvard. Teaching needs were met by the appointment of Visiting Professors Frank H. Hahn of Cambridge University for the fall term and of Gordon R. Sparks of Queens University and of Charles F. Manski of Hebrew University for the academic year. Professor Oliver Hart of the London School of Economics gave a series of lectures during the Independent Activities Period, which were enthusiastically received.

Professor McFadden was appointed to the Elizabeth and James R. Killian Class of 1926 Professorship this year. Well deserved promotions were earned by Professor Farber, who received tenure, and by Professor Kehoe, who was promoted to Associate Professor. Two new appointments have been made for next year: Olivier J. Blanchard of Harvard as Associate Professor; and James M. Poterba of Oxford University, as Assistant Professor. Ailsa Roell of Johns Hopkins University will be here next year as a Post-Doctoral Research Associate.

A major administrative change took place in January, when Professor Brown resigned as Department Head after serving in that capacity for 18 years. The Department and the Institute owe him an enormous debt of gratitude for his able and sensitive administration of the Department during that period. Fortunately, he will continue to teach and do research in the Department, and his guidance and wisdom will thus continue to be available.

ANN F. FRIEDLAENDER

Department of Humanities

Humanities Undergraduate Office

The Humanities Undergraduate Office came into being during the summer of 1982 in response to certain needs created by the restructuring of the Department of Humanities at that time. The new entity takes over a number of administrative responsibilities formerly held by the Course XXI Office, the Department of Humanities Headquarters Office, and the Office of the Dean of Humanities and Social Science. The Humanities Undergraduate Office has two main elements, the Humanities, Arts, and Social Sciences Information Center, which provides various services connected with the Institute Requirement, and the Course XXI Office, which administers major programs in 10 humanistic fields.

The Humanities Undergraduate Office is located in the space formerly occupied by the headquarters of the Department of Humanities, 14N-405, 407, 409, and 410. Director of the Humanities Undergraduate Office is Professor Travis Merritt, Coordinator is Ruth Spear. Jacqueline Bausch is Senior Secretary for the Information Center, Alexandra Tyszka for Course XXI.

HUMANITIES, ARTS, AND SOCIAL SCIENCES INFORMATION CENTER

In its first year as a component of the Humanities Undergraduate Office, the Humanities, Arts, and Social Sciences Information Center went through the partly exploratory process of defining its service role in relation to student and faculty needs and to the administration of the General Institute Requirement.

In general terms, the Center's primary function is to answer any question an undergraduate may have concerning the Humanities, Arts, and Social Sciences (HASS) Requirement, to provide as much useful information as possible about all aspects of instruction in all of the fields which the Requirement embraces, and to be able quickly and precisely to refer students to appropriate local resources when more detailed information is needed. Specifically, in 1982-83, the Center has:

1) kept on display and in circulation brochures and other printed materials describing academic programs available in each of the departments/sections/interdisciplinary areas under HASS;

2) collected in a student-accessible file copies of syllabuses and other descriptive material for most Humanities Distribution (Hum-D) subjects and for certain other HASS subjects;

3) maintained up-dated lists, semester by semester, of specific Concentration requirements and of Concentration Field Advisors (including office locations and hours) in all HASS Concentration fields; screened requests for special Concentrations; and kept Concentration statistics for all Department of Humanities fields;

4) maintained up-dated lists, semester by semester, of Transfer Credit Officers (including office locations and hours) for all HASS fields; handled Humanities Summary Sheet for transfer credit; provided information on transfer credit procedures, including those for foreign or domestic year/term away;

5) answered questions regarding substitutions and petitions concerning special cases under the HASS requirement;

6) provided staff support for the HASS Committee;

7) dispensed information and handled registration procedures for Humanities subjects in the Summer Session;

8) supplied first-year students with specific HASS information and advice via revised entries in the Freshman Handbook and notices in the Freshman Newsletter;

9) coordinated preparation of Bulletin copy for Humanities interdisciplinary subjects (the 21.900's), interdisciplinary programs (Traditions and Texts, American Studies, etc.), and special categories;

10) worked with the Chairman of the Faculty, the Dean of Humanities and Social Science, and the Registrar in establishing new Concentration forms and procedures in line with the Adjustments to the HASS Requirement voted by the MIT faculty in May 1983;

11) started preparation of a student's Guide to the HASS Requirement, covering Hum-D, Concentration, and all aspects of the Requirement, for first distribution September 1983;

12) organized the Humanities representation at the Academic Midway during Freshman Orientation Week; organized the Humanities Open House in April;

13) undertook responsibility (as of June 1, 1983) for Harvard cross-registration arrangements;

14) provided working liaison with other undergraduate offices around the Institute;

15) coordinated film orders, projectionist and equipment arrangements, student payroll, etc. for all films used in Humanities subjects.

COURSE XXI

As a part, for the first time, of the larger structure of the Humanities Undergraduate Office, Course XXI benefitted in 1982-83 from a closer definition of its functions as those associated specifically with the administering of major programs, while certain other functions formerly handled by Course XXI became the business of the Humanities, Arts, and Social Sciences Information Center. This increase in structural clarity made possible a number of important if unspectacular procedural improvements.

A second significant strengthening came through the creation of a Course XXI Policy Committee, representing all of the academic areas connected with the three degree programs; the Committee met several times throughout the year, addressing itself productively to a number of important issues.

Students: Numbers and Quality

The total number of declared majors in the three programs declined slightly this year. The May 1983 figure was 66, with 21 in the full major, XXI, and 31 and 14 respectively in XXI-E and XXI-S (a subtotal of 45 in the joint major). There were no significant new trends in the deployment of this population, either by program type or by discipline, except that among joint majors the ratio of Engineering to Science has jumped from 26/21 to 31/14. Otherwise, the general observations offered in last year's Annual Report still apply.

The academic showing of Course XXI majors was generally strong. Very few required the attentions of the Committee on Academic Performance. Better and more coordinated advising, combined with closer monitoring of progress during the term, have helped to reduce substantially the number of "crisis cases" over the past few years. If there is one general area of improvement to be worked for, it is in the overall performance in the Engineering or Science components by joint majors (XXI-E, XXI-S) who are not pursuing a second degree. It is hoped that this year's raising of the Engineering/Science requirement from four to six subjects may yield more majors whose commitment to that side of the program remains solid through their junior and senior years. Students for whom XXI-E or XXI-S is a second degree program tend to have considerably stronger records in this respect. Still, it is worth pointing out that many of our "single" joint majors perform very creditably on both sides of the ledger.

Course XXI Degrees, Honors and Post-Graduation Plans in 1982-83

One student received the S.B. in September (in XXI), six in February (two in XXI, two in XXI-E, two in XXI-S), and 23 in May (seven in XXI, 11 in XXI-E, five in XXI-S), for a year's total of 30. This is the highest number of graduating students in several years.

Several Course XXI students received noteworthy honors, awards, and distinctions. Rob Spinner, a senior majoring in Ancient and Medieval Studies, was elected to Phi Beta Kappa. Irene Baker '83, editor-in-chief of Rune, MIT's undergraduate journal of arts and letters, was nominated for Who's Who Among Students in American Universities and Colleges. Jamshied Sharifi '83, a STS/Humanities major integrating Music and Electrical Engineering, received a citation for excellence in performance and composition at the Notre Dame Intercollegiate Jazz Festival; his Course XXI thesis composition, "Suite", was performed by a 14-piece ensemble, under his direction, in Kresge Auditorium. David Waggett '83, was chosen to direct Dramashop's Spring major production, Durrenmatt's Play Strindberg.

Writing majors carried off several awards for creative and expository work. DeWitt Wallace Prizes for popular science writing went to Diana Ben-Aaron '85 and Betsy Hanson '84. David Custer '83 won the Boit Manuscript Prize, with Marissa Martinez '83 receiving honorable mention. Peter Cerrato '83 and Howard Kolodny '83 jointly received a Laya and Jerome B. Wiesner Award for their work in poetry. An Eloranta Fellowship for summer writing went to Duncan Borland '83, for his projected book on how to cope with multiple sclerosis.

Graduating seniors' plans for next year are, as usual, impressively various. Places of employment include MIT's Office of Minority Education, IBM, the Jet Propulsion Laboratory, Codex, New England Telephone, Advanced Information Systems, and Vermont Microsystems. Others will be doing advanced studies at Boston University Medical School, the Kennedy School of Government at Harvard, Oxford (Classics and Philosophy), Biola University (Ph.D. in Clinical Psychology), Stanford (Civil Engineering),

the Berklee College of Music, London's Drama Studio, the University of Southern Alabama Medical School, and MIT's Departments of Mechanical Engineering and Nutrition and Food Science.

Re-designation of the Degree for the Full Humanities Major

Completing the process of re-arranging and relabeling of degrees begun last year, Professor Merritt and the XXI Policy Committee were successful in changing the designation of the degree for the full major from S.B. in Humanities and Science to S.B. in Humanities, effective in September 1983. The clarified array of degree programs now stands as follows:

XXI S.B. in Humanities
XXI-E S.B. in Humanities and Engineering
XXI-S S.B. in Humanities and Science

First Course XXI Alumni Lecture

In November, Course XXI (with assistance from the Council for the Arts at MIT) brought to the campus for a three-day residency sculptor Rob Fisher, who graduated from Course XXI in 1961. The highlight of Mr. Fisher's visit was a multi-media lecture/presentation "Computer-Aided Sculpture and Other Natural Technologies," centered mainly on his own work. It is hoped that this event was the first in a series of annual appearances by interesting and distinguished Course XXI alumni.

Course XXI Alumni Register

To mark the twenty-fifth anniversary of Course XXI's first graduating class, the Humanities Undergraduate Office is preparing to bring out a full and detailed Register of alumni (there are nearly 1,000 at present). Questionnaires have been mailed out to all graduates. Publication is planned for late Autumn 1983.

TRAVIS MERRITT

1982-83 has been a transition year for the Anthropology/Archaeology (A/A) Program, our first with administrative autonomy and the second in our new quarters in Building 20. Despite inevitable difficulties with budgeting and other matters, the new administrative arrangement has so far been quite successful.

On the archaeological side, the Program's efforts are to a great extent identified with the Center for Materials Research in Archaeology and Ethnology (CMRAE). Despite funding difficulties, the Center's research and teaching programs continue strongly. In addition to regular graduate subjects, the success of the 1982 summer institute on metals was followed in June 1983 by an equally productive session on faunal remains, attended by professionals from around the country and abroad. Plans are underway for development of the CMRAE's research and teaching facilities to consolidate its position as the national center for materials research in anthropology.

The A/A Program is itself entering a period of rethinking and planning. Concern has focused especially on the recurrent problems of bridging the gap between basic undergraduate teaching and advanced research; of reconciling in a small faculty research strength in particular areas with teaching coverage of the field; and rationalizing staffing and temporary replacements in a discipline which requires frequent leaves. The last problem, exacerbated by the MIT hiring freeze and the loss of one faculty member, will be acute in the next two to three years, when everyone in the Program plans to take leave.

Solutions to the research/teaching gap include the CMRAE summer institute, supervision of graduate students at the CMRAE, a possible limited enrollment specialized graduate program, and faculty seminars now being developed.

A/A faculty continue to be active in research and publication; currently a majority have, in addition to articles and reports, a book forthcoming or in advanced stages of preparation. Despite strong tendencies towards individual rather than team research, an increasing convergence of interests and investigations is apparent, not only in the archaeological study of materials and technology, but also in cultural anthropology, where faculty research is creating areas of strength in symbolic anthropology, Central American studies, and the impact of the state and the world system on peasant and tribal peoples.

In terms of colloquia, seminars, and other presentations, Professors Martin Diskin and Sharon Traweek had the most impressively busy schedules, Professor Traweek speaking on the anthropological study of physics, Professor Diskin on the Central American crisis. Professor James Howe organized and chaired a colloquium attended by Panamanian Indian leaders at the 44th International Congress of Americanists. Professor Suzanne De Atley continued her work as editor of the newsletter for the Society for Archaeological Sciences.

Even in the absence of a formal graduate program, more than half the faculty members are currently involved in supervising graduate research or serving on dissertation committees in other departments and institutions.

We note with great regret the departure of Professor Wilma Wetterstrom. Dr. Frederick Wiseman of the Geography and Anthropology Department at Louisiana State is joining the CMRAE as a Principal Research Scientist, with a lectureship in the A/A Program. Professors Diskin, Lechtman, Traweek, and Steinberg will be on leave for all or part of the 1983-84 academic year.

JAMES HOWE

This academic year was characterized by curricular consolidation, a continued emphasis on literary and cultural events to supplement the curriculum, and considerable scholarly activity on the part of the faculty.

Curriculum

Total enrollments in Foreign Languages and Literatures (French, German, Russian, Spanish, and English as a Second Language) were above 1800 this year, as they had been in academic year 1982-83. Significant increases occurred in German (total 493 students, a rise of 15 percent) and Russian (total 141 students, a rise of 31 percent). Part of the increase in German was due to two subjects introduced to the curriculum this year: 21.244 German Romanticism: Fantasy vs. Reality, taught by Professor Edith Waldstein; and 21.236 German Drama Workshop, taught by Professor Michael Geisler. The latter subject offered students a unique combination of in-depth literary analysis of the works of dramatist Max Frisch and participation in a full production of Frisch's Die Chinesische Mauer (The Chinese Wall); the production took place in the Little Kresge Auditorium on December 2, 3, 4, and received much regional attention and acclaim.

Subjects in elementary and intermediate language were strengthened this year by more systematic integration of video materials in the classroom and the language laboratory. The lab's director, Ruth Trometer, was elected President of the North-East Association of Language Laboratory Directors. Nonetheless, the Section remains committed to the belief that language study cannot be divorced from the close examination of literary texts and, conversely, that the understanding of foreign literatures is best realized through study of the original languages. While many of our subjects continue to feed into interdisciplinary fields of concentration--Latin American Studies, the Film/Media Program, Women's Studies, Russian Studies--the curriculum of each of our programs is designed primarily to provide students who choose to concentrate with in-depth knowledge of specific languages, literatures, and cultures. There are currently 103 concentrators in French, 65 concentrators in German, 42 concentrators in Spanish, and 18 in Russian. This year's graduating majors wrote theses on subjects as diverse as surrealist technique in Joyce Mansour's Les Gisants satisfaits, the representation of women in Garcia Marquez's Cien anos de soledad, and (in a joint major with STS) energy proposals of the German Green-Alternative Party.

The testing program in English for incoming international students has been further refined in anticipation of the mandatory participation by all graduate departments that will begin in Fall 1983. In Fall 1982, 411 new international students entered MIT, 293 of whom took our English Evaluation Test (EET); of these, 142 enrolled in Fall semester English as a Second Language (ESL) subjects. The new requirement approved by the Committee on Graduate School Policy in Spring 1982 allows that all international students whose principal language of instruction in primary and secondary school was not English must take the EET. Enrollments in ESL are therefore expected to rise considerably. To meet better the language needs of international students, one new subject was introduced to the curriculum this year, 21.326 English II, an intermediate integrated skills subject, and three subjects were significantly revised in content: 21.335 Expository Writing for Graduate Students; 21.336 Scientific and Engineering Writing for Graduate Students; and 21.337 Workshop in Writing Research Papers for Graduate Students. A pilot program was also launched, in cooperation with the Writing Program's Writing Center, to address the special language needs of international students in a noncurricular, workshop fashion.

Special Programs and Events

Extracurricular events constitute an essential part of the educational activities furnished by the Section. These events are planned to complement specific curricular offerings, but they are open to the entire MIT community. Among the numerous events this year, those which attracted significant numbers included a presentation on student activities in the DDR by Dr. Heidrum Schorcht of the Freidrich-Schiller Universitat; a lecture by Professor Ronald Tobin of the University of California, Santa Barbara, entitled "Racine and Adler: Ideals and Inferiority"; a visit by the Australian author and filmmaker, Bobbi Sykes, who presented her film "My Survival as an Aborigine"; a lecture and reading from his new translation of Baudelaire's Les Fleurs du mal by Pulitzer Prize-winning poet Richard Howard; a talk on women and politics in contemporary Spain by the Spanish feminist Lidia Falcon; and a film festival of new works from the German Democratic Republic. The intellectual

diversity and integrity of the Section was enhanced further by the year-long presence of Dominique Rabate, a graduate of the Ecole Normale Superieure, Paris, and a participant in the MIT-ENS exchange program initiated by Professor Edward Turk last academic year. Rabate's field of specialization is contemporary fiction and literary theory. This year Steven Lewis, an MIT doctoral candidate in political science, spent the year working at the Ecole on the ideological and political development of French Socialism.

Professional Activities and Honors

Members of the Section continued to publish widely and serve in leadership capacities in scholarly organizations this year. Areas of research and publication include: medieval Slavic eulogies (Professor Julia Alissandratos); French feminist literature (Professors Isabelle de Courtivron and Kathryn Crecelius); political dimensions of Spanish Renaissance theater (Professor Manuel Delgado); operative literary aesthetics (Professor Michael Geisler); the Gnostic tradition in French literature (Professor Robert Jones); semiotic approaches to Tolstoy (Professor Krystyna Pomorska); the intellectual evolution of Spanish Civil War exiles in Mexico (Professor Margery Resnick); cinema of the French Occupation (Professor Edward Turk); narrative strategies in Rousseau (Professor Janie Vanpee); contemporary critical approaches to German Romanticism (Professor Edith Waldstein); applied linguistics (Professors Catherine Chvany, David Dollenmayer, Suzanne Flynn, James Harris); new strategies for second-language acquisition (Gilberte Furstenberg, Kathy Irving, Claire Kramsch, Douglas Morgenstern, Christopher Sawyer-Laucanno).

Associate Professor of French, Isabelle de Courtivron, was named first co-incumbent of the Edgerton Award, an MIT junior faculty prize for outstanding achievement in scholarship and teaching. (The award is being shared with Assistant Professor Warren Seering of the Department of Mechanical Engineering.) Professor De Courtivron was cited for her valuable scholarly and critical work in the fields of French fiction and women's studies and for her extraordinary abilities as a teacher, lecturer, and developer of MIT's integrated language and literature curriculum in French.

Professor Alissandratos and Professor Crecelius were awarded grants from the American Council on Learned Societies for work on literary history and theory. Professor Chvany received a grant from the Russian Research Center, where she was reelected a Fellow. Lecturer G. Furstenberg received a fellowship from the French Ministry of Foreign Affairs for advanced work in language pedagogy. Professor Geisler was awarded a grant from the MIT Council for the Arts to help produce a student play. Senior Lecturer Claire Kramsch's book, Discourse Analysis and Second Language Teaching, was nominated for the Kenneth Mildenberger Medal of the Modern Language Association. Professor Pomorska organized the Planning Conference on the Roman Jakobson Scholarly Legacy and is serving as supervisor of the Roman Jakobson Archive/Library Project. Professor Resnick served on the Board of Directors of the Abraham Lincoln Brigade Archives. Professor Waldstein, who was elected Vice-President of the Massachusetts Chapter of the American Association of Teachers of German, was also the recipient of a Mellon Summer Grant at the Wellesley College Center for Research on Women.

EDWARD BARON TURK

Like all of the disciplines in the Humanities Department, History operated during 1982-1983 for the first time as a more or less autonomous group. Although not so enthusiastic or sanguine in their expectations as the members of other disciplines in the Humanities at the prospect of a decisive move towards sectional autonomy, those in History found that it had little or no disruptive effect on their normal routine as they went about their primary task of teaching the MIT undergraduates.

Over the past few years, the History Section has seen the enrollments in its courses rise in gratifying fashion. Efforts to supplement the Section's traditional concentration on Europe and America with courses that touch other regions of the world, have been well received by M.I.T. undergraduates. Courses in the History of East Asia launched three years ago by Professor Peter Perdue now have more than respectable enrollments. The same can be said of the courses taught by Professor Philip Khoury in the History of the Middle East. The competence and growing reputation of both professors are attested to by the fact that each has been awarded a grant which will enable him to be on leave during the whole of the coming academic year to do further research in his particular field. Professor Khoury's grant, The Social Science Research Council/ACLS Post doctoral fellowship, is in addition to the Old Dominion fellowship he has been awarded. Professor Perdue's grant, The National Program for Advanced Study and Research in China, sponsored by the Committee on Scholarly Communication with the People's Republic of China, will allow him to continue his research on Water Control Systems in Early Modern China.

Following the regretted departure to Harvard of Professsor Alan Brinkley, courses in the late 19th and 20th century history of the United States were ably taught by Professor John Dittmer, holding a temporary appointment. Professor Dittmer will continue teaching next year while a major search will be undertaken to locate a permanent replacement for Professor Brinkley. The Section's offerings in American history were further enriched by the part-time appointments of Mr. Jama Lazerow and Professor Ellen Fitzpatrick. Mr. Lazerow will return to M.I.T. next year on a one-year, half-time assistant professorship. Professor Fitzpatrick has accepted a Mellon fellowship.

As noted in the report of the previous year, Professor Pauline Maier was invited to serve as the William B. Cardozo Visiting Professor of History at Yale during the spring term of the present year. She will, however, return next year and resume the office of Section Head. Professor Thomas Mahoney is also returning to teaching after four years of service to the Commonwealth of Massachusetts as Secretary of Elderly Affairs. Professor Merritt Roe Smith was away during the spring term teaching at Linsköping University in Sweden on a Fulbright Grant.

Members of the History Section continue to serve on various professional committees and commissions, to publish in and to edit professional journals, and to participate in conferences and colloquia both in the United States and abroad. Notable in this respect are Professor Dittmer, Professor Arthur Kaledin, Professor Khoury, Professor Maier, Professor Bruce Mazlish, Professor Robert MacMaster, Professor Perdue, Professor Harald Reiche, Professor Robert Rotberg and Professor William Watson.

DAVID B. RALSTON

The major problems currently facing the Literature Faculty of the Department of Humanities are posed by the unusual balance of objectives that it must pursue. The program serves the curricular needs of a relatively small number of majors (this year, the number is ten, not counting those in American Studies), but the number of concentrators is large, and the curriculum also serves other programs, in particular American Studies, Film and Media, and Traditions and Texts. It offers three tiers, comprising introductory, intermediate, and advanced subjects, aiming to meet the needs of the general student who may be drawn to literary studies only once or twice in his or her career at the Institute, as well as providing a rich program of study for students majoring or concentrating in Literature. At the same time, it tries to fulfill the important function of offering faculty the opportunity to deal with materials relevant to their ongoing scholarly concerns, establishing a level of generality which makes the texts relevant at once to both the undergraduate's interests and to the faculty's publishing careers. To an extent unusual in an undergraduate program, therefore, the curriculum lays emphasis on interdisciplinary approaches to literary study, and on theoretical, generic, and thematic subjects that range widely across geographical, linguistic, and historical boundaries. Maintaining a curriculum at this level requires staffing to which our numbers are inadequate, and we have much to do at the outset of each semester in hiring one or two competent, experienced faculty from other local institutions of higher education on an ad hoc basis. The situation is far from satisfactory both from our point of view and from that of our students, but it obviously involves problems extending beyond the financial constraints under which the Literature Faculty alone labors, and these will probably not be solved for some time to come. We have made one new appointment: Professor John Hildebidle, the author of a book on Thoreau, a volume of poetry, and several essays on American literature, will join us next term at the rank of Assistant Professor. As for the curriculum, it has recently been saluted by the Modern Language Association (MLA) for the cogency of its solution to the problem of balancing the needs of non-majors against the needs of faculty to find scholarly inspiration in their teaching, and we have been invited to lead a special session on general education at the annual meeting of the MLA next winter -- the first session on this topic in the long history of the Association.

This past year, our faculty has maintained its presence in the profession by acting in various editorial and consultational capacities and by offering papers and seminars at diverse meetings and institutions. A creditable number of articles has been published by members of the faculty this year on subjects ranging over a variety of topics: Plato, Homer, Hitchcock, Machiavelli, Grammatology, the practice of women's studies, and Solzhenitsyn, among others. These have appeared in journals such as Classical Journal, Journal of the History of Ideas, Daedalus, Transactions of the American Philological Association, Paidaeia, Women's Studies Quarterly, Radical Teacher, Massachusetts Review, and Contemporary Literature. Three essays have appeared in book format: one by Professor Peter S. Donaldson (on Cardinal Pole), one by Professor David M. Halperin (on Solzhenitsyn), and one by Professor Steven Mullaney (on cultural survivals in the Renaissance). The last of these, a mongraph of 54 pages, was selected as the leading article in the first issue of a new major journal, Representations. In addition, several articles previously published by members of the group have been reprinted as parts of scholarly collections; this includes work by Professors David Thorburn, Mullaney, Stephen J. Tapscott, and Wolff, three of whose earlier essays appeared this year in book form.

This past year saw the publication of a major work of interdisciplinary scholarship by Professor Halperin, his study of the tradition of bucolic and pastoral poetry since Theocritus, which appeared under the imprint of the Yale University Press. Two books, one by Professor William J. Paul on the films of Ernst Lubitsch and one by Professor Tapscott on William Carlos Williams, were accepted for early publication, both by Columbia University Press. Counting the production of a play as a form of major publication, one should list here that Professor A. R. Gurney, Jr. has two works in production in New York, both critical and popular successes. One of these was selected by the Kennedy Center in Washington for spring production and has appeared in various regional theaters, among them the Huntington in Boston and the Greenwich outside London, England. A new play by Professor Gurney will have its premiere at the Kennedy Center in Washington this summer.

A number of the faculty have received honors this year. Professors Donaldson and Amy Lang return to the faculty after holding Senior and Junior awards, respectively, from the American Council of Learned Societies (ACLS). Professor Halperin has been awarded a Summer Fellowship for his work on Plato, and Professor Wolff an ACLS Senior grant and a grant from the National Endowment for the Humanities for her work on Emily Dickinson. Well-deserved promotions were earned by Professor Tapscott, who was granted tenure status, and Professor Halperin, who was awarded the rank of Associate Professor.

Finally, we note with pleasure the completion of Professor Irene Tayler's book-length study of Charlotte and Emily Bronte, the continuing publication of Professor Tapscott's poetry by various magazines, and the establishment by members of the faculty, in collaboration with faculty from Foreign Languages and Literatures and elsewhere, of a new field of concentration in Film and Media Studies.

ALVIN C. KIBEL

A major factor in the life of the Music Section during 1982-83 has been the change in administration of the Humanities Department whereby each section has become an autonomous unit. Although the plan is new and leaves areas of administration yet to be worked out, the Music Section feels it has been a signal success. The new mode of administration has allowed section needs to be addressed directly and efficiently.

This is the second year in which our plan of annual rotation of chairman has been in effect. All of us in the Section consider the plan to be working successfully. The chair's work has stimulated intensive participation by the present and past incumbent, with faculty cooperation through mutually shared administration of committees.

The Curriculum Committee of the Music Section has carried out a review of present curriculum which has led to a number of new subjects for the 1983-84 academic year. They include a program in Advanced Music Performance, whereby outstanding MIT students in performance will be able to take lessons for credit, utilizing artist faculty of New England Conservatory of Music, the adjunct performance faculty of Wellesley College, and the MIT performance staff. Other subjects that have been approved include Digital Music Processing; Writing for Computer Performance; and a revision of the Beethoven course.

Subject enrollments during the 1982-83 year totalled 461 for the fall semester and 399 for the spring semester. This is not a full picture of student-faculty contact, however. To these figures must be added approximately 309 students each semester who participate in the MIT Symphony Orchestra, symphonic band, jazz bands, Choral Society and the MIT Chamber music program, though not enrolled for credit. Some students participate in orchestra, chorus, and chamber music for credit, while a far larger number are active in all these groups without course credit. In sum, section faculty throughout 1982-83 were in contact with 1,477 students in classroom and performance activities.

Close to 90 concerts were presented by the Music Section between September and June of this year. Outstanding among these were the Alban Berg Quartet attended by 800 people in Kresge Auditorium; the Phillip Glass concert, on the Abramowitz Lecture series, for which Kresge Auditorium overflowed; the concert of music by John Harbison, which was heavily attended and very favorably reviewed by the Boston Globe; the MIT Chamber Players' performance of Pierrot Lunaire, excellently attended and likewise well reviewed in the Boston Globe; an outstanding concert of Charles Ives Sonatas by Andrew Rangell and Andrew Jennings; the Western Wind vocal ensemble; the December concert of the MIT Symphony Orchestra with Swiss violinist, Ron Golan, which presented Boston premieres of works by Frank Martin and Bohuslav Martinu and received a fine review in the Boston Globe; and the Carnegie Hall appearance of the orchestra in April, which presented the New York premiere of John Harbison's Incidental Music from Shakespeare's Merchant of Venice. The concert was well reviewed by the New York Times.

We take pleasure in several recent changes of faculty status: Professor Jeanne Bamberger joined the full-time rank list of the Music Section after a joint association with both Music and the Division for Study and Research in Education. Edward Cohen, composer and staff member chiefly responsible for the program in music theory, was promoted to Senior Lecturer. Professor Stephen Erdely, ethnomusicologist and violinist, was promoted to Full Professor.

The professional activites of Music Section faculty have been extensive. Professor Timothy Aarset continues a number of research projects on performance practices in Renaissance Music. Affiliated Artist Martin Amlin gave performances in Boston and elsewhere of his own music and other contemporary works. Professor Jeanne Bamberger continues her research in cognitive development in music in connection with the Spencer Foundation of New York. She presented papers at a number of professional societies during the year. Affiliated Artist David Breitman gave concerts within the Boston area as well as at MIT. Professor John Buttrick continues his recording project of Beethoven Sonatas on the Apollo Label; the series has received favorable critical acclaim from Fanfare magazine and Stereo Review. James David Christie, Institute Organist, was noted by the Boston Globe as a "Best of 1982" for his recital last October. He has appeared in several recent recordings with the Boston Symphony and the New York Bach Ensemble.

Senior Lecturer Edward Cohen was a winner of the competition for contemporary music sponsored by the New England Conservatory during 1982-83, his works receiving performances both in Boston and in other cities in Massachusetts. Professor Jane Coppock was an invited lecturer at Radcliffe and Dartmouth Colleges and has received an Old Dominion Fellowship for the fall of 1983. She was Music Director of the MIT Dramashop production of "The Caucasian Chalk Circle" and served as consultant for the New England Foundation for the Arts. Professor James Dashow of Centro di Sonologia Computazionale of the University

of Padua was Acting Director and Visiting Lecturer in the Experimental Music Studio during the spring semester. Works of his were performed this spring by Collage and by the ensemble NewComp. He is currently working on an opera under a grant from the Rockefeller Foundation.

Professor David Epstein lectured on rhythm and tempo structure at the Herbert Von Karajan symposium of the Salzburg Music Festival during Easter Week, and gave further lectures at the International Brahms Congress at the Library of Congress and at the Brahms-Webern Festival at New England Conservtory of Music. Several new articles were published by Professor Epstein this year, and he directed the MIT Symphony Orchestra in its successful Carnegie Hall concert in April, 1983. Professor Stephen Erdely recorded sonatas by Dohnanyi and Leo Weiner for Pantheon Music. His transcription and analytical studies of Serbo-Croatian heroic songs was completed in April and is to be published in its entirety by the Harvard University Press. Affiliated Artist Gordon Hallberg led the MIT Brass Ensemble in a number of distinguished concerts at MIT and elsewhere within Massachusetts. He was on leave part of this year from his position as trombonist with the Boston Symphony Orchestra.

Professor John Harbison, on leave for a second year as composer-in-residence with the Pittsburgh Symphony Orchestra, had performances with the New York Philharmonic, Pittsburgh Symphony, and other ensembles. In numerous articles and reviews he is increasingly recognized as one of the major American composers of his generation. Steven Haflich, Lecturer in Music, attended the 1982 International Computer Music Conference in Venice, Italy. Mark Harvey, Lecturer in Music, completed his Ph.D. dissertation at Boston University on "Charles Ives and American Civil Religion". His Mass had its premiere at Christmastime and he led his big band, Aardvark, as the featured group of the First Night Jazz Festival at Berklee Performance Center. Melissa Howe, Lecturer in Music, was active in numerous performing groups on the Boston scene as well as at MIT, where she coached chamber music. Professor Lowell Lindgren delivered papers at major meetings on Baroque music held at Washington University in St. Louis and in Rome. He is the author of a section on the Baroque Era in the Schirmer History of Music, published in 1982. A new book concerning patronage of the Barberini family in Rome during the eighteenth century is due to be published by the Vatican Library.

Martin Marks, Lecturer in Music, was appointed Curator of the Library of Film Music at Harvard University, and participated in performances of this music in connection with showings of films from the pre-sound era. John Oliver, Senior Lecturer, gave outstanding performances with the MIT Chorus during the past year, and continues his notable work as Choral Director of the Boston Symphony Orchestra. Affiliated Artist Paul Orgel gave a well-received recital of the music of Debussy and Mussorgsky at MIT this spring. He was a coach and chamber music performer at the Yellow Barn Festival in Vermont during the summer of 1982. Affiliated Artist Herbert Pomeroy, together with his colleague Affiliated Artist Everett Longstreth, gave outstanding performances with the MIT Jazz Band and Jazz Ensemble throughout the year, the Festival Jazz Ensemble touring during the spring semester. Affiliated Artist Jean Rife directed the MIT Chamber Players during the leave of absence of Professor Marcus Thompson. She was in large part responsible for the outstanding success of the Pierrot Lunaire performance in May of 1983. Curtis Roads, editor of Computer Music Journal (published by MIT Press), attended the 1982 International Computer Music Conference in Venice, where he presented his composition "Field." "Field" was realized with the aid of a grant from the MIT Council for the Arts.

Professor Marcus Thompson was on leave during the spring semester to serve as Visiting Professor of Music at Eastman School of Music. He toured with the Chamber Music Society of Lincoln Center in the fall of 1982. Professor Thompson was selected in a national competition as a National Endowment for the Arts Fellow, in connection with a Recitalist's Grant. He prepared television programs for ABC Television and for the Children's Workshop Chamber Music. Roland Vazquez, Lecturer in Music, organized and conducted orchestra concerts during the IAP. He is collaborating with the original authors and with Professor Martin Brody on a new edition of the well-known textbook, The Art of Listening, authored in part by Professor Bamberger of the MIT music faculty. Professor Barry Vercoe, on leave during the spring of 1983 to pursue work at I.R.C.A.M. in Paris under a Guggenheim Foundation grant, also attended the 1982 Computer music Conference in Venice, Italy. Claudia Von Canon, Lecturer in Music, had a new book, The Inheritance, published by Houghton-Mifflin in spring 1983. Affiliated Artist Marek Zebrowski gave concerts in the Boston area and elsewhere during the past year, as well as a well-received recital at MIT.

The music program at MIT grapples with several major problems. Paramount among these is inadequate space, both for classrooms and for concerts. We lack an adequate small hall for chamber music concerts. Furthermore, Kresge Auditorium badly needs better acoustics. This major performance hall at MIT, moreover, is coming under increasing pressure for multi-purpose use, making it progressively less available for concerts and rehearsals.

The sense of the faculty this year is that our undergraduate music curriculum is in good basic shape, and that our program is ready for greater development in advanced work in the areas of performance and in music theory and its integration with performance and composition. This theoretical work has interdisciplinary implications for areas of science at MIT. Morale is high. The faculty feels its self-administration is working well, and that music at MIT is ready for a new stage of growth.

DAVID M. EPSTEIN

Faculty and program development continue to be major objects of consolidation in the MIT Writing Program. This year, the Program's Executive Committee (E. Chodakowska, K. Manning, J. Paradis) reviewed with program members the three key subject areas of the program: (1) Exposition and Rhetoric, (2) Creative Writing, and (3) Science and Technical Writing. This review was undertaken partly to assess Program offerings in light of the needs and interests of the MIT community and partly to chart more clearly a plan for faculty development. Two basic subjects were introduced in Creative Writing and Technical Communication to establish a triad (with Expository Prose) of introductory subjects for students wishing to satisfy the new Institute Writing Requirement.

The 1982-83 review also reaffirmed the Program's policy of integrating three different writing areas within the program. Most members teach in at least two of these areas, and our diverse faculty collaborate fully in teaching writing at MIT.

Student enrollments in the Writing Program have been steady over the past three years. There is a slight growth in the number of students taking Writing Program subjects, but the numbers of writing majors and concentrators has remained consistent. Student enrollments divide about equally, among Exposition and Rhetoric, Creative Writing, and Science and Technical Writing. One new phenomenon this year has been a growth in the number of students expressing interest in completing a writing major within Course XXI, in order to prepare for employment as professional science and technical writers in industry and publishing. A number of corporations and government agencies are also expressing interest in hiring MIT writing majors as professional writers.

Program development in the Writing Program has traditionally been vigorously interdepartmental. In 1982-83, the Coop Writing Programs, jointly sponsored with the School of Engineering, continued to develop at both undergraduate and graduate levels. New models of undergraduate Coop writing instruction were developed by program members jointly with faculty members in Mechanical Engineering and Aeronautics and Astronautics. The Undergraduate Coop now reaches more than 800 MIT students annually. The Graduate Cooperative Writing Program, which tests and instructs graduate engineering students in writing, expanded this year to the Department of Electrical Engineering and Computer Science and is scheduled to develop in the Department of Chemical Engineering in 1983-84. Seven out of 8 engineering departments now participate. In addition, Graduate Cooperative Writing Programs continue to evolve in the Sloan School of Management (Prof. JoAnne Yates) and the Department of Urban Studies and Planning (Dr. Louise Dunlap).

The Writing Requirement passed by the faculty in the Spring of 1982 still poses some planning and budget unknowns for the Writing Program, especially in the coming academic year (1983-84), when the Requirement officially takes effect. In Fall, 1982, testing conducted by the Committee on the Writing Requirement identified more than 200 students as having basic writing problems. Some of these students took introductory writing subjects in the Writing Program in 1982-83, but no major impact on program enrollment was apparent. It remains to be seen just what the effect on Program enrollments will be in 1983-84; we plan to offer several additional sections of introductory writing courses. We are also planning to help departments develop undergraduate cooperative writing instruction within schools other than the School of Engineering, so that their students will have additional options for meeting the second stage of the Writing Requirement. In the second stage, students must demonstrate competency in writing professional prose within their chosen majors in science or applied science. We expect that our collaboration with the Committee on the Writing Requirement will continue to develop to the benefit of both MIT students and faculty.

Another interdepartmental project of the Writing Program has been the establishment and development of an MIT Writing Center. Conceived in 1981, the Writing Center has grown quickly in the course of a year and a half, with student use of its facilities tripling this past year. Run by Dr. Steven Strang, the Writing Center offers both drop-in consulting services for students, staff, and faculty, and a popular series of noontime seminars on writing. These seminars, initiated by Dr. Strang, were taught by members of the Writing Program and Foreign Languages and Literature -- often with standing room only. The first year and a half of operation has shown the Writing Center to be a popular resource for the MIT community. The center will also play an important role in helping students meet the Writing Requirement. Support for this program has been given by the Provost's office, the Dean of Humanities and Social Science, and the Writing Program itself; long-term funding needs to be found for this program.

The Readings Committee of the Writing Program (R. Becker, F. Howe, M. Richardson) engineered several well-attended readings in 1982-83. Alice Walker, author of The Color Purple, and Toni Cade Bambara, author of The Salt Eaters, visited the program to read from their works and discuss their art with students and faculty from the MIT community. Poets Donald Hall and Arturo Vivante also gave readings. In addition, the Writing Program sponsored, jointly with the Boston Museum of Fine Arts, a performance and reading by author-musician John Cage. Other readings sponsored by the Writing Program included a visit by Berton Roueche, the scientific medical sleuth, and Samuel Florman, author of The Existential Pleasures of Engineering. Next year, the Program will sponsor a readings series featuring Gwendolyn Brooks, Margaret Atwood, and Grace Paley.

Faculty research and writing are conducted in many areas and published in a variety of forms too numerous to detail: historical study of women faculty at MIT, (Professor Rae Goodell); biography of Rosa Luxemburg (Professor Elzbieta Chodakowska); a novel set in post-war Germany (Ilona Karmel); textbook on research writing (Professor James Paradis); study of the history of Zionism (Professor Bernard Avishai); changing status of animals in nineteenth century England (Professor Harriet Ritvo); electronic mail in office communication, internal communication in American businesses in the late nineteenth and early twentieth centuries (Professor JoAnne Yates); philosophical basis of technical writing (Professor David Dobrin); biography of sculptor Mary Edmonia Lewis (Professor Marilyn Richardson); collection of short stories about women (Professor Robin Becker); study of California coastal seabirds (Professor Ellen Chu); study of Franz Ingelfinger's editorship of New England Journal of Medicine (Professor Barbara Gastel); textbook on modern writing style, study of Iris Murdoch (Dr. Steven Strang); collection of his short stories from the New Yorker and elsewhere (Frank Conroy); textbook on writing computer technology (Dr. Charles Sides).

The faculty have received a number of honors this year. Professor Harriet Ritvo received an Old Dominion Fellowship, as well as a Visiting Fellowship to the Yale Center for British Art; Professor Yates received a Mellon Fellowship to study modern historical documentation; Professor Becker received a residency grant from the Helene Wurlitzer Foundation; Professor Goodell continues to serve on the Executive Committee of the National Association of Science Writers, as well as on the Committee on Public Understanding of Science in the American Association for the Advancement of Science; Professor Yates will serve on the Research Committee of the American Business Communication Association; Frank Conroy will continue to serve in 1983-84 as the Director of the Literature Section at the National Endowment for the Arts; Professor Barbara Gastel has been selected to spend the next year in Peking, China as a guest of the Chinese government to help found a writing school.

There were several changes in faculty and personnel in the Writing Program this past year. Prof. William Bennett left the Writing Program to become a science media consultant for television. Prof. Thomas Postlewait left the Writing Program for a position in the Drama Department at the University of Georgia. In addition, the Writing Program carried out a successful search for a science fiction writer, appointing Joseph Haldeman, winner of numerous science fiction awards, as Visiting Associate Professor of Fiction. Maxine Kumin, the Pulitzer Prize-winning poet, will be a Visiting Professor of Poetry in the spring of 1984. Muriel Zimmerman, editor of Energy Abstracts, will join the Writing Program, as Lecturer in Technical Communication. James Paradis, Associate Professor of Technical Communication, was promoted to tenure and will head the Writing Program in 1983-84.

JAMES PARADIS

Department of Linguistics and Philosophy

The Department is pleased to note that its Linguistic program has, for the third consecutive time, been ranked No. 1 in the country and that its Philosophy program has been ranked No. 8, according to the most recent survey of the Conference Board of Associated Research Councils.

One of the Department's major problems continues to be graduate student support. We have not yet been able to replace satisfactorily a long-standing NIMH grant, which terminated a year ago. We are, however, applying to both federal agencies and private foundations for assistance.

The number of NSF Fellowships awarded to students entering and continuing in the Department has remained fairly constant. Other sources of outside support have been the Fulbright program and foreign governments (e.g., Canada Council). In spite of a lack of job opportunities, especially in philosophy, the number of applications to both programs has not significantly decreased, nor has the high quality of the candidates. Moreover, both programs achieved 100% employment for candidates who completed their doctoral program requirements during the year. The Department continues to receive many more requests than can be accepted for visiting scholar status.

Faculty research during the year in linguistics included: government and binding theory and the parametricization of grammars (Institute Professor Noam A. Chomsky); Warlpiri lexicography, the grammars of non-configurational languages, and the grammar of Irish (Professor Kenneth L. Hale); the primitives of phonetics--the parameters along which speech sounds are perceived and organized in humans (Institute Professor Morris Halle); Spanish phonology and morphology, their interaction with each other, and their bearing on ongoing work in metrical and autosegmental phonological theories (Professor James W. Harris); connections between syntactic and semantic features of natural language and methodological questions about the nature of linguistics (Professor James T. Higginbotham); metrical phonology and (with Professor Kenneth W. Stevens of the Department of Electrical Engineering and Computer Science) a theory of redundancy involving distinctive features (Professor Samuel Jay Keyser); aspects of lexical morphology and phonology--word formation and its interaction with phonology, and the principles which govern the operation of phonological rules (Professor Paul Kiparsky); problems of zero anaphora viewed in cross-linguistic perspective (Professor John R. Ross).

In philosophy, faculty research included conceptual problems about mental representation and an articulation of an approach to conceptual role semantics (Professor Ned Block); the connections between systems of modal logic and various concepts of provability in formal systems (Professor George S. Boolos); facets of the question: What is Logic?, including the formal properties of relations of implication, the concept of logical form, Frege and Russell on the nature of logic and its relation to mathematics (Professor Richard L. Cartwright); completion of a book On Democracy (with Joel Rogers), an analysis of the American system in the framework provided by a more general theory of capitalist democracy, and a contrasting model of a more fully democratic order (Professor Joshua Cohen); a study of various aspects of privacy in ethics and law, and examination of individual and institutional responsibilities as response to violent pornography (Professor Judith W. DeCew); studies in philosophy of mind and foundations of cognitive science (Professor Jerry A. Fodor); phenomena such as causation, knowledge, rational decision, explanation and counterfactual dependence, which indicate a profound dissimilarity between the past and future orientations of time (Professor Paul G. Horwich); various studies of scientific change (Professor Thomas S. Kuhn); scientific, literary, and philosophical concepts of love in the twentieth century (Professor Irving Singer).

Professor Kuhn was awarded the George Sarton Medal, by the History of Science Society. The Sarton Medal, established in 1955, recognizes contributions to the cause of furthering the history of science. This award coincided with the twentieth anniversary of the publication of Professor Kuhn's book, The Structure of Scientific Revolutions, The University of Chicago Press.

Professors Cohen and DeCew were each awarded an Old Dominion fellowship for one term. Professor Wayne O'Neil spent the fall term in Beijing, China, working with a small group of linguists, and the spring term at Tsuda College, Tokyo, as a visiting scientist in linguistics. Professor Judith J. Thomson spent the fall term at Yale Law School as visiting professor of law, and the spring of 1983 at the University of California, School of Law (Berkeley), Jurisprudence and Social Policy Program, as visiting professor.

Books published during the academic year by members of our faculty include: Some Concepts and Consequences of the Theory of Government and Binding, L. I. Monograph No. 6, MIT Press, 1982, (Professor Chomsky); The Philosophy of Mind, MIT Press, 1983 (Professor Fodor); Problem Book in Phonology (Professor Halle with G. N. Clements), MIT Press, 1983; Syllable Structure & Stress in Spanish, L. I. Monograph No. 8, MIT Press, 1983 (Professor Harris); Probability and Evidence, Cambridge University Press, September 1982 (Professor Horwich); Explanation in Phonology, Foris, 1983 (Professor Kiparsky).

We are pleased to announce the promotion of Professor Block to professor of philosophy.

Two resignations occurred during the year. Professor Joan W. Bresnan, who spent the year at the Center for Advanced Studies in the Behavioral Sciences at Palo Alto, will join the linguistics faculty at Stanford University and also continue her work on lexical functional grammar with Dr. Ronald Kaplan at Xerox Parc. Professor Edwin W. McCann has accepted a position in the philosophy department at the University of Southern California. And, after 20 years at the Institute, Professor James F. Thomson has retired. We wish all of them well.

SAMUEL JAY KEYSER

Department of Political Science

Departmental morale and accomplishments remain high despite financial pressures affecting both faculty and graduate students. The most troublesome problem continues to be the inadequacy of the Department's financial aid resources for graduate students. Fellowship funds at the Department's disposal have in fact declined significantly, as foundation grants raised in more affluent times have run out. Compared to our leading competitors at both private and public institutions, we are at a particular disadvantage with respect to the amounts of assistance we can offer first-year students. That we have held our own thus far in recruitment of the most promising applicants is a tribute to the Department's reputation and to the persistence and ingenuity of our students in uncovering sources of fellowship and research support within and outside of the Institute.

Research and training grants generated by the faculty are a critically important component of the financial picture. We are heavily dependent - more so than one might wish, indeed - on a small number of reasonably well-funded programs such as the Research and Training Program in Arms Control and Defense Policy, the Research Program in Communications Policy, and the Technology Adaptation Program. The educational and research programs of the Whitaker College and the Program in Science, Technology, and Society have also been valuable sources of employment or stipends for graduate students. It is characteristic, and suggestive of ways in which this Department differs from its counterparts in other universities, that most of the larger research programs in which our faculty and students participate are interdisciplinary, policy-oriented enterprises involving members of the Schools of Engineering and of Science.

Equally important for the Department's intellectual and financial structure are the larger number of small-scale projects which provide research opportunities for one or more graduate students to work with individual members of the faculty. Research grants in political science certainly require more time and effort to raise than in the past, and are often less generous, but the overall flow to the Department does not appear to have diminished as sharply as had been feared a year or two ago. It is particularly encouraging that virtually all of the Department's untenured faculty members have, this year or last, succeeded in raising funds either for a period of research leave or for continuing part-time support while in residence.

The Institute faculty approved last fall the Department's proposal for a new S.M. degree in Political Science and Public Policy. This degree program, in which about ten students have been enrolled for next fall, offers concentrations in four different fields of public policy: defense and arms control; science, technology, and public policy; communications policy; and international development. The program is designed both for mid-career professionals and for recent college graduates seeking training for jobs in government agencies, the media, business, banks, and non-profit institutions. Although some students may find the program a valuable stepping-stone toward a Ph.D., most applicants are expected to aim for policy positions in non-academic settings. The more flexible S.M. degree in Political Science remains available, but we anticipate that the majority of master's level candidates will in future opt for the more specialized policy degree program.

The Graduate Program Committee, under Professor Myron Weiner's leadership, has recommended a number of revisions in the requirements for the doctoral program. One set of changes approved by the faculty was aimed at curtailing the tendency of a few students to choose their special fields of study in such a way as to shape an overall program that seemed either excessively narrow or somewhat lacking in intellectual coherence. A further revision involved rethinking the "political analysis" requirement, which constitutes the core of the program for all doctoral candidates and developing a new set of subjects in the concepts and methods of the social sciences. Another important curricular change is approval of a proposal prepared by Professor Suzanne Berger to offer a new field of specialization in Political Economy. There are now about eight political economy subjects offered in the Department, several of them taught jointly with members of the Economics Department and the Program in Science, Technology, and Society. A year's course in economics is required as a prerequisite for work in this field, which examines the theoretical and empirical dimensions of relations between the state and the economy.

No major changes were made in the undergraduate program, which is scheduled for a comprehensive review next year. Overall enrollments have held up well, although the number of undergraduates electing to major in political science has declined slightly. In particular, the Public Policy variant of the Political Science major is not attracting much interest and needs a thoughtful review.

It is not possible to do justice to the variety and volume of faculty research in the space allowed. At the cost of being arbitrary by failing to mention those whose research has appeared in article rather than book form, let me note the books published or sent to the publisher last year. Professor Hayward R. Alker was editor and co-author of a book on Dialectical Logics for the Political Sciences. Professor Berger edited and contributed to Religion in West European Politics. Professor Walter Dean Burham published a study of The Current Crisis in American Politics as well as a college-level textbook called Democracy in the Making. Professor Nazli Choucri authored one book, Energy and Development in Latin America, and edited another on Population and Conflict. Assistant Professor Joshua Cohen sent to the publisher a book co-authored with Joel Rogers called On Democracy, an analysis of the American political system in the context of a broader theory of capitalist democracy. Assistant Professor Stephen M. Meyer published a book-length study in the Adelphi Papers series on "Soviet Theater Nuclear Force Planning". It was a two-book year for Professor Ithiel de Sola Pool: Forecasting the Telephone: A Retrospective Technology Assessment, and Technologies of Freedom, an analysis of the ways in which changing communications technologies and regulatory practices are affecting communications policies and freedom of expression in the United States. Professor Lucian W. Pye continued his work on Chinese politics with a book on Chinese Commercial Negotiating Styles. A book by Assistant Professor Richard J. Samuels, The Politics of Regional Policy in Japan: Localities Incorporated? is scheduled to appear in a few weeks time. Professor Weiner's research on India continued with publication of India at the Polls: The Parliamentary Elections of 1980.

Several faculty changes merit mention. Professor Alan A. Altshuler, my predecessor as Department Head and a leader in research and teaching on public policy, has taken a leave of absence to serve as Dean of the Graduate School of Public Administration at New York University. We wish him well in this challenging position but are hopeful that he will be back with us in due course. Professor Peter H. Smith, who has been serving as Head of the Department of Humanities and Associate Dean of the School of Humanities and Social Science, is returning next year to full-time teaching and research in Latin American affairs; we are pleased that he will make this Department his base of operations for the future. Some well-deserved promotions should be recorded here: Deborah A. Stone has been appointed associate professor with tenure, while Stephen M. Meyer and Brian H. Smith have been promoted to associate professor. Edwin Diamond, Senior Lecturer for some years, has been named Adjunct Professor.

A major change must be reported at the staff level as well. The Department's Administrative Officer, Elizabeth A.M. Terlingen Merkle, has decided to retire before the start of the next academic year. A large piece of our history goes with her, since she arrived in 1955 as the Department was beginning to take shape and subsequently became its first Administrative Officer. There can hardly be anyone associated with the Department whose life has not been enriched by her sensible advice and friendly assistance. Anne M. Grazewski, who has been serving with great effectiveness as administrator for graduate student affairs, has been named her successor.

Finally, I regret the need to record the death last July of Emeritus Professor Norman J. Padelford, the first tenured political scientist at the Institute. Starting in 1944 he built up the political science section in what was then the Department of Economics and Social Science. A specialist in international relations, Norman Padelford had a distinguished career as teacher, author, and expert consultant on questions of international law.

DONALD L.M. BLACKMER

Department of Psychology

The new undergraduate course in cognitive science has proven an unqualified success in its first year. Twenty-three students enrolled as Course IX majors, three graduated in June, and the Director of the program, Professor Dan Osherson, estimates that the coming year will see enrollment rise to 40. The new course and several new subjects have significantly increased our undergraduate enrollment over previous years. The success of this program stems both from the enthusiasm of the faculty and a widening recognition of the importance of an approach to human intellect which draws upon strengths unique to this Institute deriving from psychology, linguistics and philosophy, and computer science.

Enrollment in our graduate program has remained roughly constant. However, we recently raised the graduate support stipend by 37 percent in order to make it more commensurate with the cost of living and to meet the competition. This increase has stretched our funds to the utmost and forced us to look for additional sources of support for graduate students. To some it may seem strange that graduate trainees are supported financially even at a subsistence level. We believe that this policy is dictated by two considerations. First, trained scientists are a national asset. Second, unlike members of other professions (law, medicine, etc.), scientists generally cannot look forward to large incomes from which they can repay debts incurred in educating themselves.

Several changes have either occurred or are anticipated in the status of our faculty. Professor Emilio Bizzi takes on the directorship of the Whitaker College of Health Sciences, Technology and Management as of July 1, 1983. His assumption of this role ensures that appropriate support will be given to new developments in the brain sciences within Whitaker College. It will assure cooperation between anticipated new faculty in neurobiology and those of our Department as well as other concerned programs. Nelson Kiang, Eaton Peabody Professor of Communication Sciences, was jointly appointed to Whitaker College and this Department effective July 1, 1983. Professor Shimon Ullman was granted well-deserved tenure. John Hollerbach was appointed assistant professor, thereby strengthening our computational approach to the control of movement. Jeremy Wolfe was appointed assistant professor as of July 1, 1983, after a thoroughgoing search. His appointment strengthens the core of the Department, namely the experimental approach to behavior.

Research support for the Department as a whole has once again increased by roughly 10 percent. This increase may appear modest, but it occurs against a background of either level or decreasing funding by the federal agencies upon whom we are most dependent for support. It represents a tribute to the success of our faculty in maintaining their preeminence in the fields they represent. On the other hand, federal grant funds are now obtained under increasingly constrained conditions. It is more difficult than ever to fund innovative research ideas and shifts in the scientific interests of investigators. These developments lead to a scientific conservatism which can only be countered by the availability of alternative funds. These come largely from non-government sources such as private foundations. They allow of new ventures. We are continually seeking such support with its attendant advantages.

Our faculty and staff continue with their highly productive professional careers, guiding their laboratories and publishing at least 69 journal articles, 52 chapters in books, seven books, and numerous other communications. In addition, they serve the professional community in ways ranging from lectures to professional audiences, to reviews of manuscripts, to consulting for government agencies. Departmental service on the part of every faculty member has been the rule along with teaching by lecture and other forms of didactic supervision. Honors have come to many of our faculty including Professor Walle Nauta who received one more Honorary Doctor of Medicine, this time from the University of Zurich. Professor Tomaso Poggio received the Columbus Prize of the International Institute of Communications in Genoa, Italy. Professor Richard Held was awarded the Warren Medal of the Society of Experimental Psychologists at San Diego.

If this Department faces problems, they are more from an embarrassment of riches (other than monetary) than from a dearth of such. As Walt Kelly has written, and Paul Gray has repeated, we are surrounded by insurmountable opportunities. Our faculty and staff are involved in many research and educational efforts jointly with other entities at the Institute. The Whitaker College, the Center for Cognitive Science, the Artificial Intelligence Laboratory, the Laboratory for Neuroendocrine Regulation, and the Health Sciences and Technology Program represent a few of these commitments. The centrifugal forces exerted by these entitites must be balanced by equally strong centripetal forces if we are to maintain a unified Department, which is the wish of our faculty.

RICHARD HELD

Program in Science, Technology, and Society

Undergraduate teaching has continued to be a main activity of the Program in Science, Technology, and Society (STS). Students are still discovering STS and its offerings —its undergraduate and graduate subjects, its field of concentration in the humanities, and its joint and double majors. Student evaluations praised the quality and content of the subject offerings. Over the last year, the STS curriculum committee honed the curriculum to include a core of basic subjects to be offered each year by a Program member and more collaborative subjects with departments in related fields.

STS supported nine or so graduate students from three departments — Political Science, Electrical Engineering, and Economics — by providing fellowships and/or office space. In addition to taking subjects in STS, these students were supervised by a faculty member in the Program. All valued their particular connections with the Program, since their work centered on issues on which expertise was among STS faculty.

Our faculty served on numerous Institute committees, ranging from the MIT Press, to the Committee on Educational Policy, to the Committee on the Writing Requirement. This service has exposed faculty members to experiences useful in our own Program development at the Institute.

RESEARCH AND HONORS

Several members of the faculty received recognition for their on-going research and scholarly distinction. Professor Charles Sabel won a MacArthur Prize Fellowship. He spent the year as a Fellow in the School of Social Science at the Institute for Advanced Study in Princeton. Professor Merritt Roe Smith won a Guggenheim Fellowship, a National Science Foundation Award, and a Fulbright Fellowship. He spent part of the year as a Fulbright Scholar at the University of Linköping in Sweden. Professor Leo Marx received a Rockefeller Award which enabled him to work on his forthcoming book.

SEMINAR SERIES

An informal luncheon series provided a forum for diverse MIT faculty and associates to meet and discuss current issues surrounding science and technology. Participants around the Institute have commented favorably on our sponsorship, where we have a reasonable weekly lunch and good conversation on interesting topics. A more formal seminar series, usually biweekly, brought together renowned scholars from within and outside MIT to discuss a range of topics from medical education for Canadians to neutrino exploration of the earth.

THE VANNEVAR BUSH FELLOWSHIP PROGRAM

STS launched the Vannevar Bush Fellowship Program in the Public Understanding of Science and Technology. Funded for a five-year period by grants from the Sloan and Mellon Foundations, this program will bring eight experienced science journalists, from both print and electronic media, to the Institute for a year. They will devote a substantial part of their time to an STS seminar and related work designed to expose them to the interaction of science, technology, and society, and the remaining to gaining an intimate understanding of current developments in some particular field of technology or science in which the Institute's departments and laboratories play an important role.

STS has secured Victor K. McElheny as the leader of the Fellowship Program. Mr. McElheny, a Principal Research Associate, is an experienced and successful science journalist and has worked successively for the Boston Globe, Science, and The New York Times.

Over time, we expect the Bush Fellowship Program to grow in importance and somewhat in scale. The role of print and electronic journalism in explaining to the general public -- i.e. the collection of non-specialized publics with respect to each specialty -- what goes on in the growing variety of specialties that make up the fabric of our society becomes increasingly central in our social and political life. More and more of these specialties are technological and scientific, and helping journalism do its job better is a task of great and increasing significance.

THE MELLON FELLOWSHIP PROGRAM

The Mellon Fellowship Program is directed at researchers in engineering and science disciplines who wish to spend a year examining the problems of the social interactions of science and technology. Funded five years by the Andrew W. Mellon Foundation, the program was announced last year, and the first group of Fellows came this academic year.

THE EXXON FELLOWSHIP PROGRAM

The Exxon Fellowship Program was set up a few years ago for scholars in the humanities and social sciences to pursue researches in the history and social interactions of science and technology. The STS Program provides them with an opportunity for interaction with the scientific and technical community of the Institute to the benefit of their researches. Funding for this fellowship program has been provided by the Exxon Education Foundation.

PROGRAM IN TECHNOLOGICAL LITERACY

The Sloan Foundation has given grants to ten liberal arts colleges in the New England and Upstate New York areas to develop programs at their own institutions around technological literacy. This program aims at providing students in these colleges with an exposure to the technology which creates the artifactual world in which we all live. There is a specific emphasis on the use and significance of computers. MIT has been asked to be coordinator and the resource institution for these colleges. Under the leadership of Professors Leon Trilling and Margaret MacVicar, the Institute has organized a series of seminars at the participating colleges. This series posed some of the issues and questions that the programs at these colleges should address. After this year's trial run, MIT is now proposing to the Sloan Foundation to continue to be a resource center and guide for the ongoing programs of the participating colleges. Professors MacVicar and Trilling would continue to act as the leaders in this endeavor. An Institute-wide committee chaired by Herbert Richardson, Associate Dean of the School of Engineering, oversees MIT's overall involvement, while STS continues to act in a directive and supportive role.

STS AND AFFIRMATIVE ACTION

STS is committed to affirmative action in all of its activities. The fellowship selection committees made special efforts to identify minority and women candidates. If these candidates were not appropriate for an STS fellowship, extra effort was made to forward applications around MIT for further consideration in other fellowship programs. One STS member, Professor Kenneth R. Manning, began to help the South Carolina Commission on Higher Education think through the state's desegregation plan as it regards developing STS programs for local colleges and communities.

CARL KAYSEN

Sloan School of Management

The principal major activities of the Sloan School continue to focus on research dealing with important management issues and on the education of both practicing and potential management professionals and of the educators of the next generation of management professionals and researchers.

The following sections report on the School's teaching programs and research during the past year and on the broad array of related professional activities in which the School's faculty and staff have engaged in that same period.

Our undergraduate program, but principally our master's programs and executive education programs, are our principal opportunities for affecting the quality and practice of management, not only in this country but in others, through the dissemination of our own and many others' ideas impinging on that practice.

Our doctoral program is aimed essentially at the training of future educators of management professionals and at training these persons to engage in the serious research which must underlie any successful efforts at professional education.

Our research activities have continued to seek to create and replenish intellectual capital as the basis for understanding and resolution of important management issues, not just in relation to today's headline perspectives but geared for the longer term and thrust.

All of these activities continue to merit the high national and international repute of the School's programs and research.

In this introduction to the report of the School's activities, I should like to provide an update on the summary of progress we have been making in implementing the agenda the School set for itself in the course of the extensive review of our activities two years ago.

As I pointed out last year, the basic tasks we set for ourselves centered on the selective investments we needed to make in a regrouping of a number of our disciplinary and application domains into broader areas or clusters to encourage and strengthen intellectual interaction and to promote better linkages with others within the School and at MIT; in the creation of incentives for more cross-disciplinary and integrated recruitment, teaching, and research to permit us to deal more effectively with a number of critical managerial policy and strategy issues which are difficult to come to grips with through more partial analyses; in the review of several of our ongoing teaching programs and in the exploration of some exciting new possibilities for more focused, rather than general management, educational programs for alumni/ae and other executives; in the substantial strengthening of our efforts in external relations, including alumni/ae relations, our dealings with corporate sponsors, and our media and information relations activities; and, finally, in a substantial strengthening of the School's resource development activities.

I described our academic reorganization last year. The beneficial consequences of having reorganized ourselves into three large areas--Management Sciences, Applied Economics and Finance, and Behavioral and Policy Sciences--are already evident. The less fragmented and more general perspectives encouraged by the reorganization and by the discussions leading to the reorganization have permitted us this year to begin our recruiting to fill gaps and upgrade weaknesses with more input from more groups than we have typically had in the recent past. For example, in our recruiting to fill specific substantive gaps in our behavioral research activities, we had extremely helpful contributions from faculty who had earlier been separated by our more segmented organization and we emerged with a resultant consensus on appropriate appointments which I think truly surprised all of the participants. We have also begun to leverage our existing faculty capabilities and capacities by bringing related talents together in some joint teaching and curriculum redesign activities in our program and area steering committees.

We have established or strengthened a variety of organizational aids to further internal communication and the opportunities to learn from one another. Our faculty as a whole has met, on average, twice per academic year during the past two years; a School Council has met quarterly for the discussion of School-wide issues; the area heads meet with the Deans and the staff on a bimonthly basis; and there are biweekly administrative staff meetings. We have begun to publish a biweekly calendar of Sloan School events which is distributed to the School's faculty, staff, and students. We have succeeded in funding a faculty seminar series (the Germeshausen Lecture Series) to help bring distinguished academics to visit with our faculty and staff for several days and to share with us some of their recent work and thought. Professor Herbert Simon, a recent Nobel Laureate in Economics, will inaugurate this series in the fall of 1983. Working paper summaries are now reviewed for more effective distribution within the

School. We have begun to learn more from and about one another and our work and interests through more elaborate personnel reviews during staffing and promotion discussions, both within the areas and in our personnel committee. Finally, with the completion of our facilities renovations scheduled for summer 1984, we will have made possible the relocation and regrouping of faculty offices to encourage further these opportunities for reinvigorated internal communication and learning from one another.

With respect to our program reviews, as I noted last year, we had to eliminate, albeit reluctantly, our Accelerated Master's Program to permit us some slack to undertake both the expansion and reinvigoration of some of our ongoing programs and the development of new ones. We have now attained our planned steady state enrollment for the near term in our Master's and our Senior Executive Programs. This fall 200 master's students will matriculate and we will have our first class of 50 senior executives arriving in September.

Our Master's Program Committee has spent the year in an intensive review of the master's program core curriculum and has proposed some new and exciting possibilities for major core redesign which, when implemented, should prove to be a genuinely pioneering effort. The management science portion of the core will be focused around a "decision support system" emphasis to afford students both a better understanding and a clearer sense of the relationship in an application context of the tools and concepts we teach. There have also been several exciting new concentration packets put together for the program committee which draw upon the closely coordinated talents of several groups in the School.

A committee established last year to review new program possibilities has completed an initial draft of a report suggesting a number of options for new executive program offerings which focus upon work in areas where Sloan enjoys comparative advantages which match important market needs and interests.

We have also begun exploring the possibilities of some new dual degree or joint concentration possibilities with colleagues in other departments: in the areas of manufacturing systems engineering, in ocean transportation and other transportation areas, in construction, in real estate management and development, and so on.

The quality of program life has also been improved through enhanced opportunities for our students and our faculty to meet, visit, and work with an array of distinguished speakers and guests made possible once again through an effort at institutionalizing this kind of contact with the outside. We have had an increase in these visits from and linkages with managers beyond what had been an already substantial flow which existed through contacts in the ongoing research of our faculty and our research centers, through the consulting activities of our faculty and staff, through the many seminar speakers invited at the individual initiatives of faculty, and so on. We have built upon this substantial base of contact the additional linkages with major managerial figures made possible by the inauguration a year ago of our Distinguished Speakers Series and through the introduction of annual major School-wide "big events" --such as last year's symposium on Japanese management, which brought together several hundred managers for several days of discussion amongst themselves and with our faculty and students. Our Sloan Fellows Convocation, this fall's "big event," will focus on a number of important international management questions and will feature a distinguished panel of visitors. We have also established an executive committee of the School's Visiting Committee which provides both wisdom and help in furthering the School's contacts with key management figures in the world. We have established a corporate sponsors seminar series and inaugurated an executive-in-residence program. Area-wide seminars with managers and guests have increased in number and improved in quality. New joint projects in centers, like the Center for Information Systems Research, Marketing, Industrial Relations, Operations Management, Accounting, and so on, have been funded and often include the active participation of outside managers as well as the infusion of financial resources to help develop these projects. Finally, through the configuration of a number of broad coordinated thesis workshops, we have been able to enhance faculty and student contacts and work with outside managers on important projects of mutual and joint interest to ourselves and to others.

The quality of program life has just as significantly been improved by the quality of working life as a consequence of the major changes which have occurred in our continuing physical plant improvements and renovations. We have better teaching facilities, better facilities for learning and studying, better socializing space--including improved dining space--better space for placement interviews, for alumni/ae relations and corporate sponsor activities. With the completed renovation of the old Webster Building, now known as One Amherst Street, we have a single major site for interdepartmental centers in which Sloan faculty play a major role. The Sloan Management Review has new and better space. We have made good use throughout the East Campus of our new Prime 850 and the terminal room facilities. We have decentralized word processing and we have planned for adequate space to permit us to implement the Sloan School's personal computer project which will enable us to implement our new master's program core design and to continue our experiments in management education in our executive programs as well.

Finally, we have continued to strengthen our efforts in external relations, including alumni/ae relations and our resource development activities. We have created and filled a new position, Director of Alumni/ae Relations and Information. We have recruited and hired a new Placement Director. We have added some additional support staff but have had substantial help from our alumni/ae in upgrading our relations with them. Our graduates have taken the lead not only in providing us with important input on what needed to be done but also in putting in place a class agent structure and in getting under way a major initial alumni project for our degree program alumni. Our alumni/ae continue to receive and write appreciative letters about the School's comprehensive Annual Report. We have continued our alumni/ae summer gatherings begun two summers ago and held in several cities around the country. Our alumni/ae magazine SLOAN has now published its third issue this summer and has been exceedingly well received both by alumni/ae and by others who receive it. The letters from the Dean continue to receive responsive support from the School's alumni/ae. Visits by our faculty and staff to Alumni Council meetings throughout the country have continued during the year and we have continued to improve the style in all of the School's publications which we began several years ago. A number of alumni/ae have also committed themselves to working with the School in reviewing and improving the process and results of the School's affirmative action efforts. The Council for Opportunity in Graduate Management Education (COGME) has undertaken a major long-range planning study in which the Sloan School will play an important role. I have assumed, effective next year, both the chairmanship of COGME and membership on the long-range planning committee of COGME in an effort at seeking to effect a quantum shift in affirmative action results not only at Sloan School but throughout graduate management education in the country. We have been promised both financial and staff support from a number of organizations anxious to cooperate in these efforts.

With respect to resource development, we have established a faculty committee on resource development and an administrative subcommittee which has begun to work well in developing and beginning to implement a plan for increasing the resources of the School. We have continued to improve linkages with MIT's Resource Development, Alumni Council, and Industrial Liaison Program personnel. We have participated in joint symposia sponsorship and worked well together both in contacting and in developing possible School donors. The corporate sponsor symposia held twice a year which I noted earlier have helped to encourage new corporate sponsors to join and the results of our alumni/ae efforts at providing added help for the School have already manifested themselves in the increases in unrestricted gifts from alumni/ae which came to the School last year. The School has also begun to make progress in providing funds for student support and awards and in chair commitments or near commitments to the School. We have finally, in a difficult year, been able to keep about even in our outside sponsorship and support of School research.

In sum, we have through steady progress in pursuing our agenda for the near term underwritten our old commitment to our basic design for management education and to excellence and quality in the implementation of that design. We have reconfirmed our interest and capacity not only to build improvements into that design but also to build intellectual and professional bridges amongst ourselves, with others at MIT, with our alumni/ae, with our supporters, and with other friends and associates. We have had some success at gaining wider recognition within the School of a commitment to the significance of the resource development required to attain our goals for quality in research and teaching and to gain from that commitment substantial help from the Sloan School faculty and staff as well as from central MIT administration staff. We have in this regard been extraordinarily fortunate in working with persons in the central MIT administration who both understand and are sympathetic to the School's efforts at pressing for the attainment of a perceived leadership role in addressing some of the extraordinarily complex managerial problems and issues of our times and of the future.

TEACHING PROGRAMS

Undergraduate Program

Total enrollment in Course XV for the 1982-83 academic year was 85, the same number as for 1981-82. During the year, 30 students received the degree of Bachelor of Science in Management. Sixteen of the degrees granted were in Management Science, three in Behavioral Science, two in Dynamics of Management Systems, and nine were in the following approved Special Programs: Management Information Systems (two), Finance, International Management, Marketing, Industrial Relations, Economic Systems, Management Engineering, and Architectural Management.

Six of our graduates also received bachelor's degrees from other departments, and two received the SB and SM degrees in Management concurrently. There are five students scheduled to receive two degrees in 1984.

Enrollments in the four programs for each undergraduate year are summarized as follows:

	Program 1 Special Programs	Program 2 Behavioral Science	Program 3 Management Science	Program 4 Dynamics of Management Systems	Total
4th year	16	4	18	3	41
3rd year	12	0	18	2	32
2nd year	5	3	4	0	12
Total	33	7	40	5	85

Our undergraduate core subjects continue to attract a significant number of students from other degree programs at MIT. During the past year there were 295 subject enrollments by non-Course XV students in our five undergraduate subjects. This is equivalent to 37 additional full-time students (about 45 percent of our undergraduate student body). In addition, 33 students participated in the Undergraduate Management Game during the January Independent Activities Period (IAP), 12 of whom were from other departments.

The Sloan School participated again this year in the Undergraduate Seminar Program. The seminars in this program are six-unit pass/fail subjects, often on topics not normally found in regular departmental curricula. This fall the Sloan School offered a seminar in the Management of Student Organizations, with an enrollment of 19. The seminar was taught jointly by Dr. Jeffrey A. Meldman and by Steven Immerman of the Office of the Dean for Student Affairs, with participation by Professors Thomas J. Allen and Arnoldo C. Hax and Dr. J. Morris McInnes.

The Undergraduate Program Committee began discussion this year of possible revisions to the undergraduate curriculum. One proposed change is a program focused jointly on management science and information systems. The committee plans to have its recommendations completed toward the end of the fall term in 1983.

The Sloan School's program during IAP attracted significantly more participants this year than in the recent past. Although there is no formal enrollment (or enrollment data) for most of the activities, more activities were offered this year with increased participation by both students and faculty. Among the new activities were a 10-hour series of presentations on a variety of management topics ("A Brief Introduction to Management") featuring Professors Allen, Richard P. Bagozzi, Stewart C. Myers, William F. Pounds, and Dr. Meldman, and two films and a discussion on group conflict and cohesion ("Human Conflict: Functional or Dysfunctional") hosted by Professor Bagozzi. The School's IAP activities were coordinated by Dr. Meldman.

Two MIT awards were received this year by members of the undergraduate program community. Arlene Roane, a senior in the Management Science Program, received the Karl Taylor Compton Prize for outstanding contributions in promoting high standards of achievement and good citizenship within the MIT community. Esther Merrill, our Undergraduate Program Coordinator, received the James N. Murphy Award which is given to an employee whose sustained spirit and loyalty exemplify inspired and dedicated service, especially with regard to students. The Murphy Award was presented to Ms. Merrill personally by President Gray.

The undergraduate program was chaired by Dr. Meldman, with Ms. Merrill serving as program coordinator, as just noted. Professors Allen, Gabriel R. Bitran, Stan N. Finkelstein, Stephen C. Graves, Peter M. Senge, and M. Anthony Wong served as undergraduate advisors, together with Dr. Meldman and Ms. Merrill. Professor James B. Orlin served as the Sloan School's coordinator for MIT's Undergraduate Research Opportunities Program (UROP).

Master's Programs

Commencement 1983 marked the graduation of our last class in the Accelerated Master's Program. The decision to phase out that program made possible an increase in the size of our two-year program without straining our facilities. From 1,453 applicants for admission we have selected a September 1983 entering class of 200 highly qualified individuals. Our second year of experience with the recently revamped admission process brought further refinements in our data-management system, enabling us to operate more smoothly and keep on schedule.

The Master's Program Committee has undertaken to study the structure of the core curriculum of the master's program, with subcommittees considering the three general areas of Management Sciences, Applied Economics and Finance, and Behavioral and Policy Sciences, and reporting progress and proposals from time to time to the full committee.

The highly successful Distinguished Speakers Series has continued to attract enthusiastic audiences. Among the speakers chosen by the board of master's students were: Roger Martin, Chairman, Saint-Gobain, Pont-a-Mousson; John S. Reed, Vice Chairman, Citicorp/Citibank; Betty Hollander, President, Omega Engineering Co.; James B. Farley, Chairman, Booz, Allen & Hamilton; David R. Clare, President, Johnson & Johnson, and Joseph R. Chiesa, President, McNeil Consumer Products Company, Johnson & Johnson; Ole Skaarup, Chairman, Skaarup Shipping Corporation; and O. B. Butler, Chairman, Procter & Gamble.

Several special awards were made to master's students for academic excellence and professional promise. In 1979 the Alexander Proudfoot Company established two fellowships at the School to honor the memory of its founder and to develop an awareness that productivity is a major concern for American industry. The 1983 Proudfoot Fellows were first-year students Belden M. Menkus and Mark R. Trusheim. David D. Liu was named the second recipient of the Bendix Fellowship, which was established in 1982 to honor a first-year student. The Digital Equipment Corporation has for the second year awarded scholarships to first-year women students in our master's program. These scholarships are intended to encourage women possessing technical backgrounds to pursue management careers in the high technology industry. The Sloan recipients who were selected by DEC's Women's Advisory Committee are Kathryn A. Kasper, Lucy S. Rakov, and Sharon E. Tucker.

John S. Robotham was selected as the 1982-83 Ford Scholar. The award was established at the School by the Ford Motor Company fund to be presented annually to a second-year student. Another second-year student, Marc Yagjian, was the recipient of the Henry B. duPont Scholarship, which was established by the Crestlea Foundation, with a gift from the late Henry B. duPont. Steven P. DeRaedt was chosen to receive the Thomas M. Hill Prize, awarded annually to a second-year student who has demonstrated excellence in the field of accounting. This prize was established by the late Professor Hill's friends and colleagues to honor his memory and distinguished service to the School for 30 years. David A. Weber was named the second Seley Scholar, an award which was established in 1982 by Mr. and Mrs. Louis E. Seley to honor a graduating master's student for outstanding academic achievement and exceptional promise of business leadership.

We also presented the Brooks Prize for the best master's thesis in 1981-82 to Theresa I. Carter and Zofia B. Mucha, who co-authored a thesis entitled "Impact of Time and Order of Market Entry, Advertising, and Positioning on the Expected Market Share of a New Product: An Empirical Test." Receiving honorable mentions were Lawrence R. Kahn, and co-authors Zafer G.J. Achi and Geoffrey P. Mott. This prize was established by E. Pennell Brooks, first Dean of the School.

The following table presents a profile of the graduating classes of 1983 and 1984. The decline in the numbers of graduates will be reversed in 1985 when we should graduate our first class of 200 master's candidates.

Profile of Graduating Master's Classes		1983		1984*	
Number of Candidates		172		152	
	U.S. Citizens	136		127	
	Foreign Citizens	36		25	
Women		37		45	
Members of Minority Groups		9		4	
Median GMAT Score (national average is approximately 460)		650		640	
Undergraduate Grade-Point Average (out of 5.0)		4.3		4.3	
	Humanities	6%		5%	
	Social Sciences	24%		34%	
	Physical Sciences	21%		23%	
	Engineering	38%		26%	
	Pre-Professional	11%		12%	
Average Years Full-Time Work Experience		3.3		2.8	
Age at Admission	Under 23 years	15%		18%	
	23-24	28%		30%	
	25-26	20%		28%	
	27-28	18%		6%	
	29 and over	19%		18%	
Geographical Areas Represented		Home	College	Home	College
	New England	41%	39%	43%	50%
	Mid-Atlantic States	19%	22%	16%	14%
	South and Southeast	6%	2%	6%	5%
	Midwest	8%	12%	7%	7%
	Far West	7%	8%	13%	13%
	Foreign Countries	19%	17%	15%	11%

* Projected.

Placement Office activity showed signs of an improving economy during 1982-83. Although employers approached on-campus recruiting with a cautious "wait and see" attitude during the fall months, spring hiring proved to be more lively than expected. By season's end, the office had hosted a total of 140 companies interviewing Sloan School students for permanent and summer employment, up 15 percent from last year.

Just under 3,000 interviews were granted to 260 students participating in the recruiting program. The functions for which firms most actively interviewed were finance, marketing, and corporate/strategic planning. Overall, recruiting returned to the earlier peak activity levels of 1978-79 and 1979-80.

In the manufacturing sector, high technology firms enjoyed growth in an otherwise static market and actively recruited master's students. The electronics industry hired 23 percent of the master's graduates, just about paralleling last year's figures. No other single manufacturing industry hired more than 6 per cent of the 1983 class.

The more major shifts in student choice of employer came in the non-manufacturing arena. The number of students joining consulting firms dropped from 26 percent in 1982 to 14 percent this year, consistent with the reduced recruiting activity among consulting firms this past winter and spring. Even at this reduced figure, consulting attracted the highest percentage of graduating students relative to other service sector industries. Next in order of popularity was commercial banking at 9 percent, followed by computer services and investment banking.

Financial and investment services generally were active markets, drawing solid student interest this year. Although the actual number of graduates taking positions in the field does not appear high, it is significant relative to the size of the industry that three students secured positions in venture capital firms. Here the interplay of business and technology seems to offer particularly apt challenges for technically trained master's graduates.

The mean starting salary for the Class of 1983 was just above $37,300, up slightly from last year's average. Recruiters visiting the campus during the spring accurately predicted that salaries were unlikely to vary significantly from those offered to master's graduates in 1982. As they noted, employers would be remiss to offer new hires relatively high salaries, when current employees were being offered minimal raises or facing wage freezes.

This year's salary figures are also explained by the shifts in industry affiliation of graduating students. In recent years, consulting salaries have been 10-20 percent above the class mean, while commercial banks have offered salaries 12-15 percent below the average. The reversal in the numbers of graduates joining these industries in the past two years would alone account for the 1983 salary mean.

Overall, the 1983 placement season marked a return of optimism regarding employment opportunity in a recovering economy. Most graduating students had multiple job offers to choose from, and the majority reported that the position they finally accepted exactly matched their expectations.

The Master's Programs Committee was chaired by Professor Gordon M. Kaufman, who has begun the important and complicated process of reviewing the core curriculum of the program. Dr. Jeffrey A. Barks, Director of Graduate and Undergraduate Degree Programs, continued to provide imaginative and effective administrative leadership for the master's program. Miss Miriam Sherburne, Director of Master's Admissions and Counseling, completed more than 45 years of dedicated and professional service to the School, an association treasured by all of us at Sloan. Miss Sherburne, along with Harriet Barnett and James Gabbert, labored diligently under great time pressures to complete the difficult process of evaluating applications to our master's program. In December Linda Stantial, who had previously been Associate Director of the MIT Career Planning and Placement Office, became Director of Placement at the Sloan School, and displayed great skill in her new responsibilities in the face of a generally difficult economic climate.

Joint Program in the Management of Technology

The Management of Technology Program was established two years ago at MIT and is administered jointly by the Sloan School of Management and the School of Engineering. This 12-month, full-time program leads to a Master of Science in the Management of Technology. Aimed at engineers and scientists with a minimum of five years of work experience, the Management of Technology Program is striving to prepare these professionals for more senior roles in industry and government where they will generate and manage technology-based endeavors.

Conceived by Professors Edward B. Roberts of the Sloan School and J. Herbert Hollomon of the School of Engineering, Director and Deputy Director respectively of the program, program structure and curriculum were developed originally by a joint faculty committee from both schools. The program's new curriculum includes an intensive core of analytic subjects taken during the summer and at least eight new subjects, never before offered at MIT, allowing in-depth study of the management of technical people and programs. New subjects such as Managing Professionals, Marketing/Technology Interface, and Cases and Projects in Engineering Management have attracted enthusiastic registration from regular graduate students throughout MIT, as well as from program students. All program attendees also write a thesis in the area of the management of technology.

The Management of Technology Program enrolled its first, pilot class of six students in June 1981. In 1982-83 it had 8 students and will enroll 13 for the 1983-84 class. Plans are to expand eventually to no more than 40-50 students per year. Though required to have at least five years of work experience before coming to the program, students for the first three years average closer to 10-12 years of experience and tend to be in their mid thirties in age. They come from a wide variety of fields, including aerospace, electronics, research and development, and the military. Less than a third of each class has been foreign, with representation so far from several countries in Europe, also China and Japan.

Program implementation would not have been possible without the strong and effective collaboration of the Deans' Offices in both the School of Engineering and the Sloan School of Management. Substantial financial contributions to fund curriculum development from Pilkington Brothers Ltd. and Gillette Company are also greatly appreciated, as are gifts from Corning Glass Works and the Rogers Corporation.

The Ph.D. Program

The Sloan School's doctoral program, which remains one of the most distinguished in the nation, experienced another successful year in recruiting an incoming class of highly qualified men and women. A healthy 222 applications were received for fall 1982, sustaining the program's growth in recent years. Admission was offered to 25 applicants, and 15 entered the program in September; the yield rate (entrants/admissions) was typical of those realized over the past decade. The entering class included five women and six citizens from foreign countries. The major fields chosen by the 1982 entering class were as follows:

Applied Economics and Finance		4
Applied Economics	1	
Finance	3	
Behavioral and Policy Sciences		7
International Management	1	
Management of Technological Innovation	2	
Organization Studies	2	
Strategy and Policy	1	
Systems Dynamics	1	
Management Sciences		4
Management Information Systems	1	
Marketing	1	
Operations Management	1	
Operations Research	1	

A major shift that continues in recent years has been the growth in the proportion of foreign applicants. The foreign share of all applicants has increased from around 40 percent in 1970 to 64 percent in 1982. This shift has been reported by most other leading US management schools. We have cooperated with the efforts of the American Assembly of Collegiate Schools of Business (AACSB) to recruit more qualified US applicants.

For some time now, the median time taken to complete the Sloan School's doctoral program has been around 4 years, and about 80 percent of the program's graduates pursue academic careers. In 1982-83, 14 doctorates were granted in Management. Of those, eight assumed academic positions at the following institutions: Harvard (two), Purdue, University of Nebraska, University of California at Berkeley, University of Virginia, Simmons College, and Illinois Institute of Technology. The remaining six accepted non-university research positions.

The Doctoral Program Committee, headed by Professor Richard Schmalensee, has grappled with a number of difficult and interrelated problems. Maintaining the long-established size of the program (ideally, 20 new students each year) without sacrificing quality has proven difficult in the face of stiffening competition from other management schools, even though demand for Ph.D.s to staff management schools here and abroad continues to outstrip the available supply. Our main rivals are able to offer much more attractive and longer-term financial awards to the most attractive applicants, and the aggregate supply of qualified US applicants has not responded to the excellent career prospects for management Ph.D.s. The Doctoral Program Committee has recommended a minimal set of changes in our financial aid policies designed to make it possible for the Sloan School to maintain its position of leadership in doctoral studies. But, even though considerable progress has been made in expanding the program's resources, these minimal changes cannot be implemented until additional funding can be secured.

Even if our current program size and quality can be maintained, incoming classes of 15-20 are spread across many major fields. Several areas thus lack a critical mass of doctoral students and are unable to offer the number of doctoral-level subjects and seminars they would deem ideal. A new doctoral seminar in behavioral science has performed a valuable integrative function, and changes in the program's breadth requirements have recently been made. Here, too, further progress depends on the availability of additional scarce resources.

Alfred P. Sloan Fellows Program

On May 27, 1983, 55 Alfred P. Sloan Fellows were awarded the degree of Master of Science in Management. The Class of 1983 reflected a broad diversity of backgrounds and interests, and again was drawn from organizations from the United States and abroad. The Sloan Fellows Program was the first executive education program in the United States, and is now in its 52nd year.

Just prior to their graduation, the Sloan Fellows completed a three-week International Management Field Trip to Europe. They visited with leading government and industrial representatives in West Germany, Hungary, the Soviet Union, and France.

A comparison of the Class of 1982-83 with previous classes follows:

	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83
Industry								
United States	21	25	26	31	30	31	30	28
International	11	11	14	10	11	13	15	13
Government								
United States	11	8	8	5	5	8	7	10
International	1	1	5	2	1	0	0	2
Other								
World Bank	0	1	0	0	0	0	0	0
Municipal Management	1	1	0	0	0	0	0	0
Medical Management	6	6	2	6	6	2	4*	3*
Church Management	1	0	0	0	0	0	0	0
University Management:								
United States	2	1	0	0	2	1	1	1
Foreign	0	0	0	0	1	1	0	0
	54	54	55	54	56	56	55	55

* Medical Management Sloan Fellows also counted in US Industry and University columns.

The demand for the program continues to be strong and the quality of the nominations is extremely high. On June 17, 1983, the Class of 1983-84 arrived; there are 57 participants in the 1983 program. The current class is the largest in the history of the program.

Countries represented in the program are: Argentina, Belgium, Canada, Finland, France, India, Israel, Italy, Japan, Jordan, Korea, Malaysia, New Zealand, Norway, Pakistan, Saudi Arabia, Taiwan, Republic of China, and West Germany.

The Director of the Sloan Fellows Program, Alan F. White, is an alumnus of the program (Class of 1971) and once again performed efficiently and effectively in a very challenging role. Professor Arnoldo C. Hax served as chairman of the faculty program committee.

Health Management Executive Development Program

The eighth year of operations was completed by the Health Management Executive Program as an integral part of the Alfred P. Sloan Fellows Program. There were three Sloan Fellows from the medical field: Marianne Kunschak, Assistant to President and Director of R&D, Head, Investigational Drug Unit, Immuno Aktiengesellschaft fuer chemisch-medizinische Produkte, 72, Industriestrasse, A 1220 Vienna, Austria; James H. Raddin, Jr., LT COL, USAF, MC, Chief Aeromedical Advisor, Life Support System Program Office, Aeronautical Systems Division, ASD/AESA, Wright-Patterson Air Force Base, Ohio; and Dennis C. White, Assistant Director, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts.

Oversight of the special aspects of this portion of the Sloan Fellows Program was shared by Professor Edward B. Roberts and Mr. White.

Program for Senior Executives

During 1982-83, the MIT Program for Senior Executives enrolled 60 men and women in two sessions. The majority of the participants continue to be sponsored by United States industrial organizations, with the remainder coming from public utilities, financial and business services, and the federal government. Approximately 25 percent of the senior executives come from abroad.

During the year, a core program faculty was named to review, redesign, and carry out the curriculum of the program. Serving in this capacity were Professors Bitran, James S. Hekimian, Robert B. McKersie, Michael S. Scott Morton, Eli Shapiro, Glen L. Urban, and Martin Zimmerman.

Professor Scott Morton continued as chairman of the program faculty and Dr. H. Scott Duncan as program director.

Greater Boston Executive Program

Twenty-one men and women from 12 Boston area organizations enrolled in the Greater Boston Executive Program (GBEP), now in its 26th year of operation and held this year from January 28 to May 6.

Representatives serving on the current Administrative Committee of the program are from W. R. Grace and Company, John Hancock Mutual Life Insurance Company, Alpha Industries, Inc., Polaroid Corporation, Boston Edison Company, New England Telephone Company, and the Federal Reserve Bank of Boston.

Summer Programs

During the 1982 Summer Session, Sloan School faculty were responsible for 14 Special Summer Programs.

Professor Roberts again directed the two-week program Management of Research, Development, and Technology-Based Innovation and the one-week session on The Dynamics of Health Service Systems: Strategic Planning for Complex Health Organizations. In these programs he was assisted by other members of the School faculty, including Professors Allen, Richard Beckhard, Finkelstein, Hax, Mel Horwitch, Dorothy Leonard-Barton, Urban, Eric A. von Hippel, Visiting Associate Professor Ralph Katz, and Senior Lecturer John F. Rockart.

Preceding the Health Systems course, Professor Finkelstein directed a new one-week program -- Management of Medical Technologies and Health Care Practices: Development, Utilization, and Cost, which was co-sponsored by Tufts University School of Medicine, Office of Continuing Education. He was assisted by Professors Allen and Roberts, and physicians, economists, and other scientists from MIT, Tufts, Harvard Medical School, The State University of New York at Stony Brook, and the National Institutes of Health.

Professor John D.W. Morecroft and other members of the System Dynamics Group again offered the two-week program on Corporate and Economic Policy: The System Dynamics Approach.

Professor Stewart C. Myers of the Finance Group, assisted by Professor Gerald A. Pogue of Baruch College, the City University of New York, presented the two one-week programs on Modern Concepts in Financial Management and Models for Financial Management and Planning. A new offering by the Finance Group was the one-week program International Corporate Finance, chaired by Professor Donald R. Lessard.

Professors John J. Donovan and Stuart E. Madnick offered the popular two one-week courses in the management information technology field: Advanced Software Concepts--Operating Systems and Key Aspects of Information System Technologies: Database Systems, Telecommunications, and Performance Evaluation. There was also a new program in this area: Professor Hoo-min D. Toong's one-week session on Personal Computers: Structure, Evaluation, Application, and Hands-on Experience.

Members of the Accounting and Control Group offered two one-week programs, both chaired by Dr. McInnes --Corporate Planning and Control Systems and Financial Analysis and Accounting for the Non-Financial Executive. Other participants in the programs were Professors Hax, Ram T.S. Ramakrishnan, H. David Sherman, and Dr. Rockart.

In the operations management area, Professor Hax directed the one-week program Strategic Planning Systems. Professor Scott Morton of the School, and Walker Lewis, Founder and President of Strategic Planning Associates, also participated.

Professor Jeremy F. Shapiro, who also serves as Co-Director of the MIT Operations Research Center, presented a one-week program --Resource Management: A New Approach to Corporate Planning.

In addition to these programs offered as part of the Institute's Special Summer Program, several members of the faculty and staff directed and participated in two other seminars. The School's Center for Information Systems Research offered its seventh annual summer seminar--Current Issues in Information Systems: Managing the Growing User Demand--at the Hyatt Regency Hotel in Cambridge.

The Marketing Center of the School conducted a three-day seminar on Marketing Strategy and Models in the Information Age. This was held at MIT's Endicott House in May. Parallel sessions were held on industrial products and consumer products.

Industrial Liaison Symposia

Members of the School's faculty were responsible for three of the major symposia sponsored by the Industrial Liaison Program. In the fall Professor Roberts chaired a one-day program, Management of Research, Development, and Technology-Based Innovation. Professor Jeremy F. Shapiro offered a half-day program--Resource Management Systems for Logistics Planning. During the spring term, in April, Professor Thomas A. Kochan was in charge of a day-long program, US Industrial Relations in Transition.

In addition, the Sloan School and the Industrial Liaison Program jointly offered a two-day program in November at Kresge Auditorium--Effective Business Management: Lessons from Japan--chaired by Dean Abraham J. Siegel. Papers were prepared in advance by prominent Japanese industrialists and faculty. The authors introduced the papers at the conference, members of the School faculty then commented on the topics and moderated the floor discussion sessions. A volume of the conference proceedings has been edited by Professor Lester C. Thurow and will be published in Japan and the United States later in 1983.

These special summer and liaison programs continue to serve an important dual role. They offer specific post-experience training to professional managers and consultants to managers but they continue to serve the equally important function of helping the School's faculty make substantial improvements in our year-round degree and residential programs by serving as a "proving ground" for curriculum review, innovation, and redesign.

RESEARCH

This section summarizes the major research efforts and accomplishments of the School. This work is both disciplinary and multi-disciplinary in character and is grouped here under three main headings corresponding to the major clusters within which the School's faculty are currently organized: Behavioral and Policy Sciences; Economics and Finance; and the Management Sciences areas. The section does not include detailed references to the substantial research efforts and participation of the Sloan School faculty and staff in the activities of many of the Institute's interdepartmental centers or laboratories. These are described in the separate center or laboratory reports.

Behavioral and Policy Sciences

This recently reorganized area is now a year old. It brings together about 35 faculty members with widely ranging backgrounds and interests. What they share in common, however, is a set of underlying research methodologies drawn from the behavioral sciences, a concern for policy issues, and an improved organizational mechanism for learning more about their own research from one another. These mutual interests and our new organizational design should provide the foundation for a variety of valuable interactions which will permit this area to discern better which problems to study and how better to strive for understanding the astonishing array of behavioral and policy implications of our "new information" and "high technology" age.

The area's newly established steering committee has already taken several initiatives to foster the synergy we want to encourage. The development of a new set of area-wide Ph.D. subjects in research methods and of a new master's concentration in human resource management and the discussions at two one-day research retreats have brought people together far more effectively than was possible under our former more fragmented organizational design.

The listings here of the faculty's research are fairly arbitrary in that they cannot easily reflect this enhanced awareness of the great potential for synergy or of the cross-functional mix of the various efforts involved.

Human Factors in Management. The faculty in the organization studies and industrial relations groups have in common that their primary research focuses on the human issues involved in managing an organization, as well as in the relation of organizations to one another and to the economic, social, political, and environmental contexts within which they function. Their disciplinary bases include the social and behavioral sciences of psychology, sociology, anthropology, and economics. One of the overlapping concerns of the two groups is human resource management and, in fact, an important step taken last year within the teaching programs was to establish the new master's level concentration in management of human resources noted earlier in which both groups are participating.

--Organization Studies. The faculty in organization studies have long been concerned with understanding the dynamics of behavior in organizations, especially the relationship between the individual and the organization. This work continues in several directions. Professors Lotte Bailyn, Edgar H. Schein, and John E. Van Maanen are in the finishing stages of a major project sponsored by the Office of Naval Research on careers, socialization, and organizational culture. Seven doctoral students have been participating in various phases of the project. Some 20 odd technical reports have been written to date and cover a broad range of theory, method, and substance.

Professor Schein has been focusing on unraveling the dynamics of organizational culture--how does it begin, how does it evolve, how is it embedded, and how does it change? He expects his work to culminate in a book during the coming year. Professor Bailyn is studying the career dynamics of technical professionals in R&D laboratories. During the past year she has been on sabbatical leave and during that time has added to her present base of US observations an industrial laboratory in the United Kindgom as a comparison point. Her information and insights about technical careers are of substantial interest to laboratory managers. Professor Van Maanen has been examining several distinct socialization settings for indications of precisely how cultures are transmitted from one generation of members to the next. Among his settings has been preliminary work comparing the Harvard Business School to the Sloan School in regard to the contrasting student cultures in place at each institution.

Senior Lecturer Edwin C. Nevis, working with Dr. Katz, has been studying professionals in consulting roles in service organizations. They find that these individuals have such a strong motivation for career and professional development that their employing organizations should view it almost as an organizational core mission, but that without a broadly internalized complementary organizational vision best seen as a "dream" or super-ordinate goal, individual opportunity is not sufficient to bring about enduring organizational commitment.

Research on the family-owned firm by Professors Beckhard and Schein has been going on for some time and is currently being reported in various conferences and papers. Following several scheduled extensions a summarizing book is planned.

--Employment and Industrial Relations. A major research project, "US Industrial Relations in Transition," funded by the Sloan Foundation, is in its second year. As is apparent from many indicators, fundamental changes are taking place in industrial relations in this country and it is a propitious time to take stock, document, and analyze what is happening. A series of substudies conducted individually and jointly by the faculty, often in connection with graduate students, is making good progress. Professors Harry C. Katz and Kochan and others have completed a study of the effects of worker participation processes on unions. This is a topic of great current interest and in reporting their results to union leaders they have touched off a vigorous debate. Professor McKersie has been working on two other highly topical areas: concession bargaining and the industrial relations dimensions of productivity. In the former, working with Research Associate Peter Cappelli, he has tracked the environmental pressures giving rise to concession bargaining and is now examining the terms and changes involved. The productivity work, done in conjunction with doctoral student Janice Klein, appears in a major report to the Committee on Economic Development. Dr. Katz, besides the work already mentioned, has focused on collective bargaining in the auto industry, particularly analyzing plant level measures of industrial relations and economic performance, utilizing data drawn from General Motors.

Professor Katharine G. Abraham has completed much of her work dealing with the role of length of employment service on firms' compensation, termination, and promotion decisions and is now starting to explore how firms adjust the size of their white-collar work forces in response to cyclical and trend patterns and manufacturing shipments. A further aspect of a broad concern on the part of the industrial relations faculty, not only for blue-collar issues but also for human resource management generally, is represented by Professor Thomas A. Barocci's work on information systems professionals. In conjunction with Christine Bullen of the Center for Information Systems Research (CISR), he has organized a broadly based field research program to study human resource issues in information systems departments and information systems professionals in user departments within large corporations.

Careful work on career evolution frequently requires patience while the researcher waits for individuals to move through their career stages. Professor Phyllis A. Wallace's longitudinal study of master's graduates of the Sloan School, starting with the Class of 1975, is now reaching the interesting stage. One preliminary finding, which will be carefully followed since it differs from findings reported at two other business schools, is that five years after graduation women graduates of Sloan who are full-time employees appear to do as well as their male counterparts.

System Dynamics. Research in system dynamics has been concerned with corporate policy, the energy transition from petroleum to other energy sources, and national economic behavior. Professor Morecroft has been directing the Corporate Research Program, which applies system dynamics to business decision making and strategy. Supported by a group of corporate sponsors, the program not only provides research opportunities for students but produces a base of applications that can build a foundation for theoretical work on administrative structure and behavior. Professor Morecroft has been particularly interested in the role of bounded rationality and in the structuring of system dynamics models so that they permit decision intentions to be good locally even while the same decisions may be disfunctional at a global level.

Professor Jay W. Forrester and Professor Peter M. Senge have been working on the continuing development of the System Dynamics National Model. Several technical problems have been solved by simplifying the borrowing and credit extension mechanisms, improving the financial controls, and reformulating the savings and consumption equations. The model is yielding reasonable behavior, generating endogenously the business cycle and the economic long wave. Professor John Sterman has completed an extension of

his thesis work that examines the macroeconomic consequences of alternative energy strategies. The results show that an energy strategy based on capital-intensive, long lead-time, centralized technologies creates greater economic stresses during the energy transition than a strategy based on relatively short lead-time, labor-intensive decentralized technologies. He has also developed a simple model of the Kondratieff cycle and, through a variety of tests, shows that the long wave can arise in an economy even though all the actors are behaving rationally from the point of view of the firm.

Management of Technological Innovation. The issues surrounding the competitiveness of the US in the world economy brings increased salience to the research in technological innovation that has been going on at the School for many years. In current work Professor von Hippel has a long-term interest in mechanisms by which innovators capture the benefits of their innovations. His research has shown that traditionally recognized mechanisms such as patents, lead-time, and know-how have a low and uneven effectiveness. He now plans to look for additional field-developed mechanisms that may exist in the marketplace and which may allow innovators to capture innovation benefit.

Professor Allen has been conducting studies of international and regional technology transfer at sites in Ireland and Sweden with the help of collaborators in those countries. A pilot study has been completed in Sweden. In Ireland preliminary data analysis indicates that a substantial amount of technology has been transferred through movement of people but that most of the transfer is among multinational firms. Professor Leonard-Barton has been studying diffusion of technical innovation among dentists specializing in crown and bridge work. She finds that choice of technology is influenced by experts who lobby against innovation and serve as negative opinion leaders, that choice of metals is often driven by cost rather than quality, and that professionals frequently lack adequate information to make an informed choice decision. Professor Roberts has concluded his participation in a study of comparative US-Swedish technical entrepreneurship and has initiated research on the formation and growth of new biomedical enterprises.

Corporate Strategy, Policy and Planning. The pace of change and competition in the business world has heightened in recent years causing corporations to put more emphasis on strategic issues and giving rise to a high-flying new consulting industry. Recent criticisms of that industry, however, highlight the need for more fundamental research into the strategic determinants of company success. Professor Edward H. Bowman has been studying strategic risk--the apparent negative relation between risk and return of companies within industries. In his most recent investigation he finds that risk-taking among troubled companies in the container industry does not seem to be associated with subsequent return. Professor Horwitch has turned his attention to the strategy-technology relationship. He finds a new level of complexity in technological innovation and multinational competition. Professor Scott Morton in cross-disciplinary work with faculty in the Information Systems subgroup of our Management Sciences area is embarking with Dr. Rockart and others on an ambitious new project called "Management in the 90's." The premise of the project is that changes in the information technologies (computers, artificial intelligence, telecommunications, etc.) will have a significant impact on the way firms are structured and managed as well as the strategies they will choose to pursue.

Professor Zenon S. Zannetos has continued his research on productivity and innovation. Working with several students he has been identifying impediments to innovation which cause firms and industry to mature and decline. Four industries have been selected and an attempt will be made to predict the innovative behavior of firms within these industries. As part of a research program relating organizational strategy to transaction costs and organizational networks, Professor Gordon Walker has been applying a transaction cost approach to make-or-buy decisions at a division of GM. Working with a master's thesis student, he has built a predictive model that classifies 90 percent of the historical make-or-buy decisions in their dataset correctly.

International Management. International management is closely associated with strategic issues and in the new geography of the Behavioral and Policy Sciences area the faculty of the two groups will be in physical as well as intellectual proximity. Professor Donald R. Lessard has continued his research in several areas that bridge not only strategy and international issues but finance as well. He has been studying risk and return considerations in external financing and contracting by developing countries with particular reference to Ecuador. Working with John Lightstone of New York University and the Union Carbide Corporation, he has also developed a substantially new approach to estimating the exposure of a corporation to real exchange rate fluctuations and to managing this exposure. In addition, as part of a study for the Canadian government, he has been investigating the effect of country risk on capital market equilibrium and consequently on the evaluation of projects from public and private perspectives.

Professor Richard D. Robinson has been on sabbatical leave for half of the year and during that time has been compiling and analyzing the results of 9 master's dissertations relating to 42 Japanese-owned and managed firms in the US. The purpose is to ascertain what elements of managerial style have been brought from Japan and what impact this has had on the behavior of the enterprises. Professor D. Eleanor Westney is completing a book on the adoption and adaptation of Western organizational forms in Meiji Japan from the opening to the West in the 1850s through the first decade of the 20th century. She is also starting a comparative study of the training, organization, and career paths of engineers in three Japanese and three US computer companies. This work is in collaboration with Visiting Fellow Nori Sakakibara from Japan.

Health Care Management. The Sloan School's teaching and research program in health care management advanced on several fronts. In September MIT established a new interdisciplinary center, the Laboratory for Health Care Studies, as a component of the Division of Health Policy and Management of Whitaker College, with Professor Finkelstein as Director. The Laboratory is launching a new Ph.D. program in health policy and management this coming year and has received major initial funding for its research program. During the year Professor Finkelstein pursued his research on the development and dissemination of health technology with several research projects relating to the link between medical evidence and clinical practice. Professor Roberts was also active in the area, concluding his data analysis on the development and utilization of clinical ideas and starting new research on biomedical companies.

Law. Although law is primarily a teaching rather than research area within the School, the work done several years ago by Professor J. D. Nyhart and others to introduce the MIT Deep Ocean Mining Model into the Law of the Sea negotiations received broad notice and acclaim. Professor Nyhart and Professor Harilaos Psaraftis of the Ocean Engineering Department have followed up with an MIT Oil Spill Cleanup Economic and Regulatory model. One part of this work has produced a first working iteration of a model of the US marine pollution damage liability and compensation laws. Professor Nyhart is also pushing forward on research into alternative dispute resolution mechanisms. Senior Lecturer Gordon F. Bloom has joined him in helping to establish a Massachusetts Critical Issue Forum that would study major problem areas, such as toxic wastes, plant closings, right to know laws, etc. It is hoped that such a forum of respected state leaders representing the concerned parties could, through discussion and analysis, provide an alternative to formal adversarial procedures for the resolution of some of the issues facing the state.

Economics and Finance

The Economics and Finance Group is the second broad disciplinary area on which the School's teaching programs build and whose research contributes to the understanding of both important theoretical and practical problems relating economic and financial considerations to management concerns.

During the year, Institute Professor Franco Modigliani continued his work on a National Science Foundation project investigating the relationship between the monetary mechanism and financial structure. This research led to one paper examining the effectiveness of alternative intermediate targets of the central bank in a system of flexible prices and corporate and noncorporate enterprises. Another paper examines the implication of a developed financial intermediary sector and its regulation. This paper showed that an extensive and competitive intermediary structure need not reduce the effectiveness of a bank credit target, although extensive controls on quantities and prices might impair it.

A second area of interest is the economics of public deficits as related to the life cycle theory of saving and the effects of inflation. This was the subject of the Marshall Lectures, which Professor Modigliani delivered at Cambridge University during his spring sabbatical.

Professor Modigliani has also worked on empirical studies of the life cycle hypothesis and on the development of alternative mortgage designs in an inflationary environment. He is completing his term as Vice President of the International Economic Association.

Professor Sidney S. Alexander embarked on a study of forecasting methods, with particular emphasis on financial markets. The anticipated outcome of this study is an evaluation of the relative forecasting power of autoregressive and modeling approaches, in particular whether each approach has something to contribute to the other. He also worked on the economic aspects of anti-trust case law.

Professor Ernst R. Berndt's research within the last year has continued to focus on factors affecting the demand for energy and energy-economy interactions, particularly interactions between productivity growth and energy price changes. New research initiatives include (1) derivation and empirical implementation of consumers' evaluations of new product innovations (with an application to automobile design and performance innovations in Sweden and the US); (2) a research project dealing with assessing industry performance, incentives, and regulation in the US electric utility industry; and (3) a more general theoretical research effort on defining and measuring the "quality" of products in the theory of consumer and firm behavior.

Professor Fischer Black's research in finance has concentrated in three areas: (1) the effects of deregulation on investment banking, commercial banking, and other financial services; (2) practical ways for making corporate investment decisions; and (3) simple and effective ways to reward effective effort by corporate managers, in order to focus the manager's attention on the interests of stockholders and to change management compensation to fit competitive conditions. He has also continued work on the properties of consumption and income taxes and on business cycles in the context of the general equilibrium model of the economy.

Professor Daniel M. Holland has completed his research on investor returns, corporate profitability, and costs of capital in the United States. This work was done in collaboration with Professor Myers. The final report of this research will be included in a volume edited by Professor Holland and published by the Lincoln Institute of Land Policy. This volume will include studies of corporate profitability and capital costs in nine different countries.

Professor Holland is also working on a study to determine local government's reactions to Proposition 2 1/2, which limited municipalities' revenues from property taxes.

Professor Henry D. Jacoby continued as Associate Director of the MIT Energy Laboratory, with responsibility for program areas in Energy Management Economics and Policy. His own research efforts were in two areas: (1) the analysis of world energy markets and (2) studies of the US natural gas industry. The international energy work focused principally on oil markets and the analysis of oil supply functions. The work on natural gas industry, sponsored by the US Department of Energy and by the MIT Center for Energy Policy Research, concentrated on the public policy issues of regulation of the oil pipeline industry, particularly the possible impacts of deregulation of the well-head price of natural gas.

Professor Edwin Kuh has continued as Director of the Center for Computational Research in Economics and Management Science. He has developed systematic ways to apply linear Eigenanalysis to macroeconomic models, in order to isolate strategic parameters, exogenous variables, and equations. This research should improve economists' understanding of the essential aspects of econometric model behavior. He and his colleagues at the Center are in the early stages of a research project on guided computing, in which interactive computation, suitable algebraic and graphic devices, together with list processing, help guide an econometric or statistical analyst through the many steps and decisions inherent in applied quantitative analysis.

Professor Robert C. Merton has continued research in finance and economics in the areas of capital markets, asset valuation, and corporate liability pricing. In particular, he has worked with Professor Terry A. Marsh on a study of the volatility structure of security markets and its relation to market efficiency. This research attempts to explain the observed volatility of security prices in terms of uncertainty about underlying fundamental variables, such as earnings and dividends.

As was noted above, Professor Myers collaborated with Professor Holland on a study of corporate profitability and capital costs for US corporations. In addition, Professor Myers continued his research on the effects of asymmetric information on corporate financing and investment behavior, and on applications of option pricing theory to capital investment problems. He also wrote a paper summarizing the implications of modern finance theory for corporate strategic planning. The paper attempts to build a bridge between finance theory and the literature and practice of corporate strategy.

Professor Myers was Vice President and Program Chairman of the American Finance Association for the calendar year 1982. He was elected President of the Association for 1983.

Professor Robert S. Pindyck devoted much of his research effort to theoretical and empirical work on the ways in which uncertainties about prices, costs, and rates of return affect the investment, output, and pricing decisions of firms, as well as the behavior of markets. He has used option pricing techniques to analyze investments in plant and equipment, advertising, and research and development. He has also used stock market data to measure indirectly the variance associated with aggregate rates of return in manufacturing. His results indicate a significant increase in firms' "capital risk" over the past two decades. He has also continued research on the economics of natural resources, especially the role of uncertainty in renewable resource markets. He worked with Professor Julio J. Rotemberg on a dynamic model of the demands for factory inputs in the presence of uncertain adjustment costs. They used that model to show how sudden increase in energy prices can affect investment, employment, and energy use over time. This research is related to his long-standing interest in American energy policy.

Professor Schmalensee has continued his work with Professor Paul Joskow, of the MIT Economics Department, on electric utility deregulation. They have completed a book, to be published by the MIT Press, which evaluates deregulation reforms. They have also pursued a related project focused on scale economies and technical change in coal-fired steam-electric generation. In addition, Professor Schmalensee completed a paper on localized competition. He applied techniques for detecting the presence and diagnosing the importance of localization to data on the ready-to-eat breakfast cereal industry.

Professor Lester C. Thurow's book, Dangerous Currents: The State of Economics, was published in May 1983. He is presently working on a sequel analyzing alternative economic policy for the United States economy.

Professor Marsh worked with Professor Merton on explaining the volatility of common stock prices. This work was described above. In addition, Professor Marsh investigated the time series properties of accounting earnings, dividends, and management forecasts. He has worked on a model of how management communicates information to investors through various channels. The model leads to a prediction for the stochastic process followed by accounting earnings.

Professor Rotemberg's research activities are mainly concentrated on two projects. The first is the empirical implementation of rational expectations models and the second is an exploration of monetary equilibrium models with transactions costs. His theoretical work has studied the consequences of open-market operations in both closed and open economies when people hold money for transactions purposes. In addition, he collaborated with Professors Pindyck and Thomas M. Stoker on modeling factor demands as reflecting the choices of a cost-minimizing firm.

Professor Richard S. Ruback has developed a new method to examine competition in the "takeover" market. A competitive acquisitions market implies that the potential gain to unsuccessful bidders for matching the successful offer price is not positive. He has successfully tested his hypothesis in a new paper, "Assessing Competition in the Market for Corporate Acquisitions." He also prepared a detailed case study of the Cities Service-Occidental Petroleum merger. This study explores the stock market reactions to the various announcements that led to the merger. This case study, as well as his previous case study on the DuPont-Conoco merger, shows that the stock market reacts to a variety of announcements that precede takeover, so that earlier studies that focus on one announcement are incomplete.

Professor Ruback collaborated with Michael Jensen of the University of Rochester in a review article, "The Market for Corporate Control: A Scientific Evidence." This paper reviews and synthesizes the empirical research on corporate control. Professor Ruback also collaborated with Professor Zimmerman on a paper using capital market evidence to determine the effect of unionization on the profitability of firms.

Professor Stoker continued his work on aggregation theory as applied to both macroeconomic and microeconomic models. He also continued work with Professors Dale Jorgensen, of Harvard University, and David Sleznick, of the University of Texas, on a model which characterizes the demands for energy and nonenergy commodities for individual US households, as well as the total macroeconomic demand for these commodities. The model is being used to test various hypotheses about the structure of individual family budgets, as well as hypotheses about the construction of aggregate price indexes.

Professor Zimmerman's work on the effects of unions on firm profitability was referred to above. In addition, he is working with Professor Ruback on a study of how regulators determine the allowed electric utility rate base. This work focuses on how risks are allocated in the regulatory system. Subsequent work will explore the implications of different allocations on firm performance.

Professor Zimmerman is also investigating the leasing of coal lands. This work examines the practices of the Federal Government in a leasing of federally owned coal tracts. The objective is to explore the efficiency implications of the currently used and suggested alternative procedures.

Professor Eli Shapiro was on leave for most of the academic year, while serving as President of the National Bureau of Economic Research.

Professor Paul Krugman was on leave at the President's Council of Economic Advisors.

Management Sciences

As productivity, industrial performance, and foreign competition become so widely discussed and debated throughout society, managers continue to look toward business schools as a source of talent and ideas. In particular, they increasingly seek knowledge in traditional management school strengths in decision-making, including the use of models for information and decision support.

The public's ready assimilation of microcomputers with user-friendly software such as electronic spreadsheets has further heightened managerial awareness of models and their appetites for model-based analysis.

With its long-standing emphasis on decision support models, measurement, and information systems, and its balance of contextual and methodological research, the Sloan School's Management Sciences area remains attractively positioned to contribute to these managerial needs. The area's broad spectrum of work on the generation, interpretation, and use of data; on the development, calibration, and validation of models; and on behavioral issues related to implementation and technology transfer reflects its implicit research philosophy--that good theory and good practice go hand in hand.

For example, the marketing group continues to sustain its leadership position in analytic methods and models as well as in applying these methods to real problems. The group's investigations this past year have provided new insight on individual choice behavior, market structure and competition, new products, measurement, and market information. Professor Richard P. Bagozzi continues to study attitude formation and family decision processes. Professor John R. Hauser has investigated defensive marketing strategies, agenda and choice probabilities, market structure, and pre-launch forecasting of consumer durables. Professor Urban has collaborated on these latter two topics and has also studied strategic issues in marketing, industrial marketing, and validation of marketing models. Professor Leigh

McAlister's research on variety-seeking behavior and consumer promotions has contributed to our understanding of individual choice behavior. In addition, Professor John D.C. Little and Dean Alvin J. Silk, who no longer reside within the umbrella of the Management Sciences area, continue their marketing research on the generation and measurement of marketing data and on the validation of marketing models.

As illustrated by a conference of leading practitioners and academicians held at the School last fall, the operations management group's research also maintains a balance between both theory and applications. Work this past year on inventory and production planning builds upon the group's widely acknowledged strengths in this area. This work includes Professor Bitran's research on open and closed job shops, the Japanese Kanban inventory system, and approximation methods for production planning; Professor Graves' research on operational methods for inventory and production control and multi-stage production planning; and Senior Lecturer Harlan C. Meal's collaboration on this last topic as well as his work on materials requirement planning and hierarchical planning. In addition, the group has expanded its activities in several other directions. Professor Hax has studied elusive, but important, problems in strategic planning and on linking managerial functions with the strategic planning process. Professor Charles H. Fine has studied manufacturing policy and product quality control. Professor Graves' research has also evolved into the domains of health care systems and transportation freight planning.

Any managerial study requires meaningful accounting information and effective methods for planning and control. Members of our accounting, planning, and control group continue to work on these important issues in both the private and public sector. Dr. McInnes has studied productivity measurement, financial measures in managerial control and budgetary control. Professor Peter Brownell has collaborated on this last topic and has continued to work on the effects of leadership style and organizational structure on budgetary processes. Professor H. David Sherman continues to study methods for measuring, evaluating, and improving performance of service organizations including extensions and applications of his data development analysis of multiple-input/multiple-output organizations. Professor Ram T.S. Ramakrishnan has focused on information effects in management and accounting, including studies of audit firms, financial intermediaries, and market-wide impacts.

The generation and effective use of information is now inexorably tied to computers. The management information systems group has worked across a broad spectrum of highly visible technological, managerial, and behavioral issues. Dr. Rockart and Professor Michael E. Treacy continue to collaborate on the study of executive support systems. Dr. Rockart has also continued to pursue the use of his widely disseminated critical success factor methodology, and Professor Treacy has studied decision support system generators. Professor Donovan has worked on a related topic--the use of microcomputer games as a vehicle for education. Dr. Meldman continues to consider legal aspects of computer systems, including the thorny issue of information privacy.

In the technology arena, which is a traditional area of strength for MIT, Professor Madnick continues to study database management and design as well as new structured design methodologies for improving architectural design processes. Professor Toong's long-term study of microprocessors has led him to investigate the managerial impact of personal computers.

Much of the research within the Management Sciences area draws upon previous contributions of the faculty to underlying methods in statistics, optimization, and applied probability. Members of the operations research and statistics group continue to contribute to this methodological base as well as to its application in a variety of contextual domains. Professor Kaufman continued his long-range study of methods for projecting primary energy mineral supply. In other energy-related research, Professor Jacoby has studied world energy markets and the US natural gas industry. Professor Arnold I. Barnett's research in applied probability continues to structure new problem settings, as evidenced by his several contributions to the burgeoning analysis of criminal justice systems. Professor Roy E. Welsch's research on regression diagnostics and bounded influence regression has taken him further into the exciting area of graphical analysis and to initial exploration of expert systems. Professor Wong continues to study clustering methods, classification techniques for directional data, and a variety of applications including several in the setting of health.

In the area of mathematical programming, Professor Orlin has made further progress in structuring the broad topic of dynamic/periodic optimization and has initiated research on an applied ocean vehicle scheduling problem. Professor Thomas L. Magnanti has studied methods for large-scale and network optimization, as well as applications to distribution and transportation planning. Professor Jeremy F. Shapiro has continued his study of integer programming methods and has increasingly been attracted by the application of these methods to strategic planning and logistics.

In addition to these research activities, the Management Sciences faculty has embarked upon new teaching initiatives that promise to enhance its synergies between teaching and research. In a joint initiative with the School of Engineering, the Sloan School--and particularly the operations management group--has begun to design a broad technology/management-based master's program on manufacturing

engineering. In addition, the Management Sciences area has begun to study a revision of its core offerings in the School's master's program. This revision would strive for greater integration of the component groups' teaching material, and would consider the potential infusion of personal computer-aided teaching material into the curriculum.

The outside world continues to recognize the area's research accomplishments. Professor Bagozzi was initiated as a fellow in the Society for Multivariate Experimental Psychologists and won last year's Journal of Marketing Research's O'Dell award for best paper in the journal in 1977. Dean Silk and Professor Urban won this same award for publications in 1978. They also received third place in the Management Science Institute's practice achievement award. Professor McAlister was listed in Outstanding Young Women in America, and Professor Orlin was a co-winner of the Operations Research Society of America's transportation doctoral thesis award.

EXTERNAL RELATIONS

The School's concerns in the area of external relations continued to focus on activities in four areas: alumni/ae relations, publications, information, and fund raising.

In the area of alumni/ae relations, the School sponsored its second annual series of Summer Gatherings, social occasions for alumni/ae and current students. In 1982, these gatherings took place in New York, Cambridge, Houston, and San Francisco. The School's Office of Alumni/ae Relations has also worked closely with the newly formed Graduate Management Association (GMA), the alumni association for graduates of Sloan master's and doctoral programs, to organize meetings in Cambridge, Washington, DC, Chicago, Houston, and Los Angeles. In Cambridge, Howard Johnson, Chairman of the Corporation, Professor Lessard, and Professor Pounds spoke to local alumni on three dinner occasions. The Houston meeting also included members of the MIT Energy Laboratory and the Industrial Liaison Program, brought together at a downtown Houston location to hear remarks on the future of oil prices and its effect by Professor Pindyck.

In the area of publications, the School introduced SLOAN, the new semi-annual alumni publication. The third issue was published in June 1983. The magazine is mailed free to alumni/ae of all Sloan programs (c. 11,000) and to friends of the School and other interested persons. We have also initiated efforts at improving the publication and distribution of Sloan Working Papers.

In the area of information, the School has just begun to focus additional energies on its public relations efforts and in this context also plans to work closely with the MIT News Office.

In the area of fund raising, the School has worked with the MIT Alumni Association to oversee semi-annual mail solicitations of alumni, a source of increasingly significant support for the School. The GMA's 18-month telephone campaign to raise funds to endow a room in the newly remodeled E51 in honor of Miriam Sherburne, Director of Admissions and Counseling at Sloan and a member of the MIT staff since 1937, has just gotten under way.

To provide strategic overview and coordinated implementation for these and other of the School's fund-raising plans and activities, we have established a new committee of senior faculty chaired by Professor Zannetos. An administrative subcommittee which includes the School's program directors, the directors of alumni/ae relations, of placement, and of finance and administration helps to coordinate and implement the variety of resource development activities in the School and to work closely with MIT's Resource Development and Alumni Association Offices.

The results of our resource development activities to date have been encouraging as have our other alumni-related activities. At the end of the year, the MIT Alumni Association recognized Sloan's increased activities in the alumni area with two citations. It awarded a coveted Bronze Beaver to Wayne J. Holman, a member of the first class of Sloan Fellows (1939), who has been a leader in the Society of Sloan Fellows for over 40 years and is currently a member of the School's Visiting Committee. The Association also awarded a Presidential Citation to the Sloan School (one of six organizations so honored) for its outstanding work in its alumni-related activities.

Paula Cronin, Director of Alumni/ae Relations and Information for the School, assisted by Wanda Jones and Alice Moriarty, has contributed greatly to the School's increasing effectiveness in these activities and Professor Zannetos has given energetic drive to the launching of our new resource development committee and its important set of activities.

STAFF CHANGES, PROMOTIONS, AND VISITORS

The start of the 1982-1983 academic year saw the completion of the planned reorganization of the Sloan School faculty into three major areas. John D.C. Little, the George M. Bunker Professor of Operations Research and Management, has assumed responsibility as head of the Behavioral and Policy Sciences area. Stewart C. Myers, Professor of Finance, is serving as head of the Applied Economics and Finance area. Thomas L. Magnanti, Professor of Operations Research and Management, is leading the Management Sciences area.

During the past year, three faculty members were granted tenure. Arnold I. Barnett, Associate Professor of Operations Research and Management, joined the faculty of Sloan in 1974 after earning a Ph.D. in applied mathematics at MIT. John R. Hauser, an Associate Professor of Management Science, returned to Sloan in 1980, after holding an appointment as Assistant Professor at Northwestern following the receipt of an Sc.D. in operations research from MIT in 1975. Paul R. Krugman, Ford International Associate Professor of Management, earned his Ph.D. at MIT in 1977; Dr. Krugman, who joined Sloan's faculty in 1979, has been on leave this year on temporary assignment as International Policy Economist at the Council of Economic Advisors.

Stan N. Finkelstein, a member of the Behavioral and Policy Sciences area who specializes in the management of medical technology, was promoted to the rank of Associate Professor. Dr. Finkelstein holds SB and SM degrees from MIT in chemical engineering and the MD degree (1975) from Harvard Medical School and the Harvard-MIT Division of Health Sciences and Technology.

Two other changes in faculty status occurred this year. Jeffrey A. Meldman, a member of Sloan's faculty since 1974, was appointed Senior Lecturer and Associate Dean for Student Affairs. Hoo-Min D. Toong, formerly Assistant Professor in the Management Sciences area, became a research associate.

We were pleased to welcome three new assistant professors to Sloan's faculty. Charles H. Fine, who earned his Ph.D. at Stanford Graduate School of Business, became a member of the Management Sciences area. Michael E. Treacy, whose expertise is in management information systems, is a candidate for Ph.D. at the Sloan School. D. Eleanor Westney, who received her Ph.D. at Princeton and was most recently Assistant Professor at Yale, came to Sloan as the Mitsubishi Career Development Assistant Professor in International Management. In addition to these three faculty, Dr. Leigh McAlister, Visiting Assistant Professor at Sloan during the 1981-82 academic year, accepted an appointment as Assistant Professor with the marketing group.

Kenan E. Sahin, Professor of Management at the University of Massachusetts at Amherst, spent the year at Sloan as Visiting Professor in the Management Sciences area.

Four faculty taught at Sloan as visiting associate professors. Meryl R. Louis, Associate Professor at the Naval Postgraduate School, taught part time in the organizational studies group as did Michael L. Tushman, a faculty member at Columbia University Graduate School of Business. Paul R. Warshaw, a member of the Faculty of Management at McGill University, spent the spring semester in Sloan's marketing area. Ralph Katz, a faculty member at Boston University who had previously been on the faculty at Sloan, was appointed as Visiting Associate Professor.

Two new lecturers were appointed this year. John Feingold taught a seminar in Investment Banking for the finance area. Charles M. Jonscher held a joint appointment in the Sloan School and the Political Science Department.

Two part-time visiting lecturers taught at Sloan during the spring 1983 semester. Sheldon A. Borkin, a project manager at IBM, was responsible for a section of Management Information Technology I. A consultant with Arthur D. Little, Inc., Donald B. Rosenfield, taught a portion of the subject, The Operating Manager.

During this year four faculty members were on sabbatical leave. Lotte Bailyn, Professor of Organization Psychology and Management, spent the academic year doing a cross-cultural comparative analysis of organizational situations. John D.C. Little, holder of the George Maverick Bunker Professorship of Management, retained responsibilities half time at Sloan, while working on his marketing research. Institute Professor of Economics and Finance, Franco Modigliani, was on sabbatical during the spring semester. Richard D. Robinson, Professor of International Management, was also on sabbatical.

Two faculty members were on leave of absence this year. M. Lynne Markus, Assistant Professor of Management, spent the academic year at Arthur D. Little, Inc. Associate Professor Stephen C. Graves spent the fall term participating in a Management Training Program at the Shanghai Institute of Mechanical Engineering.

Research associates who joined Sloan's staff this past year were R. Wayne Oldford, Center for Computational Research in Economics and Management Science (CCREMS) and Martin Shell (CCREMS). Other

research affiliates during this past year included Gloria Bronsema, Carolina Wardle, and Robert I. Benjamin who were associated with the Center for Information Systems Research; Oscar Rincon Diaz and Maria Rincon Polo associated with the management information systems group; and Aleksei Tikhomirov, an IREX exchange fellow, associated with the strategy and policy group.

We report the following staff changes:

Paula B. Cronin, on Sloan's staff since 1978, and most recently Director of Placement and Lecturer, assumed new responsibilities as Director of Alumni/ae Relations and Information.

Linda Stantial, formerly of MIT's Career Planning and Placement Office, became the new Director of Master's Placement. Joanna C. Kosakowski joined Sloan's staff as Administrative Assistant in the Office of Finance and Administration. Ellen Nangle and David Ames, who had formerly been members of the Sloan support staff, became Administrative Assistant for the Sloan Fellows Program and Administrative Staff Member in the system dynamics group, respectively.

We note the following departures from Sloan School during this past year: Peter G.W. Keen, Associate Professor of Management Science, who left Sloan to devote full time to private business; Peter Brownell, Assistant Professor of Management Science, who accepted another teaching position in his home in Australia; Jawaid A. Ghani, Assistant Professor of Management Science; James W. Driscoll, Assistant Professor of Management. Peter H. Cappelli, a Postdoctoral Associate, also left the School.

Finally, with great sadness we record the deaths of two colleagues. Professor Emeritus Carroll L. Wilson, a member of Sloan's faculty since 1959, died after a brief illness. Professor Wilson's lifelong research was on the interrelations of technology, government, and society, and he had been very successful in organizing major worldwide research efforts. During his tenure at Sloan, Professor Wilson served as Director of the MIT Fellows in Africa and Latin America Programs, Director of the MIT Summer Study of Critical Problems of Global Environment, Director of the Graduate Program for Social Application of Technology at MIT, and as Mitsui Professor in Problems of Contemporary Technology.

Patricia Ann Macpherson, Administrative Assistant for the Sloan Fellows Program, had been at Sloan from 1958 until shortly before her death. In her early years at Sloan, Patte worked in the Industrial Relations Section for Professors Douglas McGregor and Douglass V. Brown and later for Professor Charles A. Myers. In 1975 she joined the Sloan Fellows Program with responsibilities for alumni activities, field trips, and seminars.

ABRAHAM J. SIEGEL

School of Science

This is my second report to the President since becoming Dean of Science. I would like to note some accomplishments during the past year which I hope will contribute to the continued excellence in teaching and research of the School. These accomplishments are:

- The establishment of a five-year planning process for the departments and laboratories in the School of Science that will assist department heads and laboratory directors to shape their future with some certainty.

- The beginning of a gradual process for reducing the dependence on soft money for academic year salary recovery by providing sufficient resources to assure that new assistant professors will be appointed with full academic year salary support.

- The merger of the Department of Meteorology and Physical Oceanography with the Department of Earth and Planetary Sciences. The new Department of Earth, Atmospheric, and Planetary Sciences will create opportunities for new research and teaching activities without impairing the Institute's commitment to a strong program in meteorology.

- The beginning of a $2.8 million project to renovate the undergraduate chemistry laboratories.

- The establishment of a more streamlined, and hopefully more effective, Affirmative Action Program within the School. I remain committed to increasing substantially the number of women and minorities on the faculty of the School of Science.

I would also like to take this opportunity to thank two individuals for their service to the School. First, Professor Peter Stone has been an effective and wise head of the Department of Meteorology and Physical Oceanography. We are all indebted to him for his contribution. Second, Professor Herman Feshbach is stepping down (or is it up?) as Head of the Department of Physics after 10 years of service. It is difficult for me to express adequately my thanks to an individual whose contributions have been so great to the discipline of physics and to the Institute, and for whom I have limitless admiration and affection.

In conclusion, I must note that the outlook is for a continued period of limited resources. Accordingly, as I stated last year, difficult resource allocation decisions will have to be made. The process for making these decisions will rely heavily on the Science Council, occasional ad hoc faculty committees, and the established advisory and visiting committee structure. The views of individual faculty, staff, and students are also most welcome. We cannot permit the constraint on available resources to impair in a significant manner the quality of our teaching and research enterprise and, most importantly, our ability to move aggressively into the most promising new areas.

ACADEMIC PROGRAMS

There were 694 undergraduates in the School of Science during the past academic year, approximately a six percent decrease from the previous year. The number of minority undergraduates remained constant, and the number of women undergraduates increased by 15.7 percent. Twenty-one percent of the Institute's upperclass undergraduates were enrolled in the School of Science.

Graduate enrollments in science decreased from 1,110 in the 1981-82 academic year to 1,070 in the 1982-83 academic year. The total enrollment represents approximately one-quarter of the total graduate student population at MIT. The number of minority graduate students decreased by 11 percent, and the number of women graduate students increased by five and one-half percent.

The faculty size in the School remained constant this year. The undergraduate student-to-faculty ratio was 2.4 to 1, and the graduate student-to-faculty ratio was 3.7 to 1.

During the spring semester the School of Science held a special program for freshmen, "Talking Science", designed to give the students an opportunity to discuss their career plans with professors and upperclassmen/women from each of the science departments. The departmental open houses for freshmen continued to be held throughout the School.

Professor Anthony French, acting on behalf of the Dean, met with the academic officers from each of the departments in the School to discuss improvements in the Core curriculum.

RESEARCH

The research volume of the School of Science in fiscal year 1983 is estimated to be $68,600,000. Research activities in the interdepartmental laboratories which report to the Dean of Science were included in the estimate.

FACULTY AND STAFF

Professor Robert Jaffe, Department of Physics, and Professor Frank Solomon, Department of Biology, were co-recipients of the first School of Science Prize for Excellence in Undergraduate Teaching.

Professor Anthony French, Department of Physics, was elected Vice President of the American Association of Physics Teachers. Professor Henry Kendall, Department of Physics, was awarded the Bertrand Russell Society Award for 1982. Professor Bruno Coppi, Department of Physics, was awarded the 1983 American Physical Society, Division of Plasma Physics, Award for Excellence in Plasma Research.

Dr. Keith Nelson was appointed Assistant Professor in the Department of Chemistry. Drs. David Anick, James Gates, and Stephen Paneitz were appointed Assistant Professors in the Department of Mathematics.

We were saddened by the deaths of Dr. L. J. Heidt, Associate Professor of Physical Chemistry Emeritus, on April 4, and Dr. J. T. R. Nickerson, Professor Emeritus of Food Technology on August 16.

JOHN M. DEUTCH

Department of Biology

During the 1982-1983 year, 208 undergraduates were registered as Life Sciences majors, and 91 received the degree of Bachelor of Science in the Life Sciences. Of these, 42 were in the regular Course VII Program, 33 in the VII-A Program and 14 in the VII-B Program. Most of these graduates plan to attend either medical school or graduate school.

During the period from July 1, 1982, to June 30, 1983, 19 Ph.D. degrees were awarded in the Department and one in the Joint Program in Biological Oceanography with the Woods Hole Oceanographic Institute. The maximum number of Ph.D. candidates registered in the Department in 1982-1983 was 130, with another 21 in the Joint Program. The entering graduate class in September, 1982, was 26 and the class arriving in September, 1983, will be 25.

EDUCATIONAL ACTIVITIES

Although there have been no major changes in the undergraduate curriculum in the past year, some changes can be anticipated in the near future since a faculty committee, charged with reviewing the undergraduate programs, has been very active during the year and will certainly make some recommendations for changes in the near future.

Two new laboratory subjects in the area of biotechnology were taught for the first time in the past year. These subjects were modeled on the 24-unit project laboratories that have been taught in the Department for several years. One of the new subjects (7.15 Biotechnology I), taught during the fall semester under the direction of Professors David Botstein and Leonard Guarente, was designed to give students experience in the use of bacteria in genetic engineering. The other subject (7.16 Biotechnology II) was taught during the spring semester under the direction of Professors Phillip Sharp and Richard Mulligan and concentrated on the use of animal cells in genetic engineering. Both of these subjects have been organized to allow students to work on individual projects. This gives students the opportunity to experience the excitement of doing experimental research.

A new subject, entitled 7.33 Genetics for Graduate Students, was organized during the year and will be taught for the first time during the fall semester of the 1983-1984 year. This subject, to be taught by Professors David Botstein and Gerald Fink, was organized to meet the needs of first-year graduate students who enter the Ph.D. program with little or no experience in genetics.

The recipients of the annual John L. Asinari Awards for 1982-1983 for outstanding research by undergraduates in Life Sciences were: Peter Diamandis (supervisor, Professor Graham Walker), John Greene (supervisor, Professor Phillip Sharp), and Young Ha Kwon (supervisor, Professor Alexander Rich).

RESEARCH

The research activities of the Department are in the areas of biochemistry, genetics, microbiology, cell and developmental biology, biophysics, virology, and immunology. Individual research projects are described in the annual publication, Biology Research Summaries, available at the departmental office in 56-511.

PERSONNEL

During the past year Dr. Richard Hynes was promoted to Professor and Drs. Robert Horvitz and Alexander Varshavsky were awarded tenure. Dr. Christopher Walsh, who is appointed jointly in the Chemistry and Biology Departments, became Head of the Chemistry Department on July 1, 1982. Professor Irving London, who has held the positions of Director of the Joint Harvard-MIT Division of Health Sciences and Technology and Director of the Whitaker College of Health Sciences, Technology, and Management, resigned as the Director of the Whitaker College, to become effective July 1, 1983.

Dr. Vasken Aposhian from the University of Arizona spent the year in Professor Paul Schimmel's research laboratory and Dr. William Gelbart from Harvard University spent his sabbatical year in Professor Mary Lou Pardue's laboratory.

Professor Sheldon Penman was on sabbatical leave at Harvard University and Professor Richard Hynes spent his sabbatical leave at University College in London.

Dr. Barbara Meyer joined the Department as Assistant Professor in September, 1982. Dr. Meyer received the B.A. in Biology from Stanford University in 1971, the M.S. in Molecular Biology at the University of

California, Berkeley, in 1975, and the Ph.D. in Molecular Biology and Biochemistry from Harvard University in 1979. From 1979 to 1982 she was a post-doctoral trainee at the MRC Laboratory of Molecular Biology in Cambridge, England. Dr. Meyer's research program is concerned with the elucidation of the sex determinant factors in the nematode.

Dr. David Raulet has accepted the position of Assistant Professor of Immunology in the Department and the Center for Cancer Research. His appointment will be effective on July 1, 1983. Dr. Raulet received the B.S. in Microbiology from the University of Michigan in 1976 and the Ph.D. in Biology from MIT in 1981. He spent from 1981 to 1983 on a post-doctoral appointment at the University of Pennsylvania. Dr. Raulet's research interests are in the area of cellular immunology.

Dr. Rudolf Jaenisch has accepted an appointment as Professor, to be joint with the Department and the Whitehead Institute for Biomedical Research. Dr. Jaenisch received the M.D. at the University of München in 1967. Since then, he has held the following positions: Post-doctoral Fellow at the Max Planck Institut für Biochemie, München, 1968-1970; Post-doctoral Fellow at Princeton University, 1970-1972; Assistant Research Professor (1972-1976) and Associate Research Professor (1976-1977) at the Salk Institute for Biological Studies; and Research Professor at the Heinrich Pette Institut, Hamburg, 1977-present. Dr. Jaenisch's research interests are in the use of molecular biological methods to investigate the regulation of gene expression in vertebrates. He will join the Department as a faculty member as soon as his research laboratories, to be located in the new Whitehead Institute building, are ready for occupancy.

It is a pleasure to report on the following honors and awards received by various faculty members in the past year. Professors Phillip A. Sharp and Mary Lou Pardue were elected to the National Academy of Sciences, and Professor Sharp was also elected to the American Academy of Arts and Sciences; Professor Susumu Tonegawa was a co-recipient of Columbia University's 1982 Louisa Gross Horwitz Prize, given for outstanding research in biology or biochemistry; Professor Alexander Rich was co-recipient of the Lewis S. Rosenstiel Award for distinguished work in basic medical research, given by Brandeis University; Professor Robert Weinberg was chosen as Scientist of the Year by Discover magazine; Professor Ethan Signer spent some time as a visiting professor at the University of California, San Francisco, after having been chosen as one of only three scientists in the United States as Wellcome Visiting Professors, sponsored by the Burroughs Wellcome Co.; Professor Frank Solomon was selected as co-recipient of the first School of Science Prize for Excellence in Undergraduate Teaching; and Professor Richard Mulligan was chosen as Searle Scholar by the Chicago Community Trust.

GENE M. BROWN

Department of Chemistry

Bachelor of Science degrees in Chemistry were awarded this year to 40 undergraduates. Most of the graduates will be attending graduate school in chemistry, medicine, or related disciplines, or have taken industrial employment. The Master of Science degree was awarded to 3 people. A total of 41 Ph.D. degrees were awarded: 12 in September; 9 in February; 20 in June. To date 1708 Ph.D. degrees and 394 Master's degrees have been awarded by the Department.

PERSONNEL

Dr. Stephen J. Lippard was appointed as Professor of Chemistry. Dr. Lippard received a B.A. from Haverford College, then received the Ph.D. from this Department in 1965 as a student of F.A. Cotton. Following a postdoctoral year at MIT, he was appointed to the faculty of the Chemistry Department at Columbia in 1966 and rose rapidly to the rank of professor there in 1972. Professor Lippard has broad research interests in inorganic chemistry, including synthesis and structure determination of transition metal complexes, bimetallic clusters in chemistry and biology, antitumor platinum drugs, coupling reactions in organometallic chemistry and higher coordinate metal complexes.

Professor Dietmar Seyferth, an expert in organometallic chemistry, was named Robert T. Haslam and Bradley Dewey Professor of Chemistry.

Professor K. Barry Sharpless was the 1983 winner of the American Chemical Society's Award for Creative Work in Synthetic Organic Chemistry in recognition of his innovative work in development of new synthetic methods, most recently in the area of stereoselective oxidation reactions.

Professor Mark S. Wrighton was designated a McArthur Prize Fellow by the John D. and Catherine T. MacArthur Foundation, which entails five year support for research and scholarly activities in any area of the recipient's choice.

Professors Rick Danheiser, William Roush and Mary Roberts were promoted to the rank of Associate Professor.

ACTIVITIES OF THE DEPARTMENT

The undergraduate chemistry laboratories in Building Four are being renovated completely for the first time in 60 years. The renovation is occurring over the summer and will be a crucial factor in our ability to modernize the laboratory curriculum. In connection with the physical renovation of the instructional laboratory space, we are planning laboratory curriculum redesign with the emphasis to be expanded use of computers in education. The Department this year successfully applied for a VAX 780 computer, which will be a major resource, and we anticipate 10 IBM personal computers will be dedicated to the undergraduate laboratory space. A proposed replacement of the introductory chemistry sequence 5.40, 5.41, 5.42 by a revised three semester sequence of general and organic chemistry lecture courses has been approved by the Departmental faculty and will be up for Institute-wide approval in the 1983-1984 academic year.

The Department was privileged to host lecture series sponsored by the Arthur D. Little Professorships. Professor Heinz Gerischer of Fritz Haber Institute in Berlin presented A.D. Little Lectures in inorganic and physical chemistry entitled "Photoelectrochemical Energy Conversion with Semiconductors";"Spectral Sensitization of Solids"; and "Photocorrosion of Solids". Professor John Morrison of the Australian National University visited the Department for one month as A.D. Little Professor, and presented three lectures in biological chemistry entitled "Hysteresis and the Slow-Binding Inhibition of Hexokinase by M[III]ATP Complexes"; "The Mechanism of the Reaction Catalyzed by Dihydrofolate Reductase"; "The Interaction of Folate Derivatives with Dihydrofolate Reductase from Bacterial and Vertebrate Sources: pH-Dependence and Slow-binding Characteristics"; and "Characterization of a Bifunctional Enzyme from E. Coli: Production, Control and Kinetic Properties of Chorismate Mutase-Prephenate Dehydrogenase". Professor Emanuel Vogel from the University of Koln was the Northeast Coast Lecturer for 1982, and lectured on "Bridged Annulenes: From Exotic Species to Viable Molecules."

The program of the Chemical Sciences Industrial Forum, a group of industrial associates of the Department, included a two day symposium on "Transition Metals in Synthesis and Catalysis" in June, arranged by Professor Richard Schrock, and featured Professors Seyferth, Schrock, and Sharpless from the Department with five professors from outside MIT. There are 13 member companies in the Forum.

RESEARCH

Analytical

Professor Biemann's major activity is directed toward the determination of the structure of proteins by a combination of either the Edman degradation or DNA sequencing with the mass spectrometric method which he has developed over the years. He works in collaboration with research groups who carry out either the Edman degradations or the DNA sequencing work. Recently they have determined the sequence of alanine-t-RNA synthetase (which consists of 875 amino acids) in collaboration with Prof. Paul Schimmel at MIT, and then glutamine-t-RNA synthetase (550 amino acids) with Prof. Dieter Söll at Yale. They are now working with Prof. Schimmel on glycine t-RNA synthetase and will soon start on the glutamine acid enzyme with a group in Ottawa. These enzymes (which all have been isolated from E. coli) play a crucial role in the process of protein synthesis as they are the machinery which recognizes which amino acid is the next to be linked to the growing protein chain and accomplish it with the help of the proper t-RNA. Thus, they are intimately involved in the recognition of the genetic code.

In a related program, Biemann studies the variation of structure of a smaller enzyme, thioredoxin, which occurs in all cells procaryotic and eucaryotic, including mammals. It is hoped that these studies will lead to an understanding of the phylogenetic relationship of many organisms, eventually even the archaebacteria. Only the E. coli thioredoxin is completely known, and they are developing a mass spectrometric "mapping techinque" to determine the structural differences among these enzymes.

The laboratory is also involved in the NIEHS Program (Principal Investigator, G. Wogan, Department of Nutrition and Food Science, MIT) on the Study of the Health Effects of Fossil Fuels. Participation is concerned with the chemical identification of the compounds produced by combustion of oil, coal or shale in furnaces or engines (chiefly using mass spectrometry).

Biological

Professor Gobind Khorana's group has been analyzing visual receptor biochemistry by analysis of a bacterial model system. The first event in vision is the absorption of light by photoreceptors located in rod and cone cells of retina. The mechanisms by which light energy is converted to electrical signals are completely unknown. They are interested in studying the chemistry and biochemistry of the early events in visual processes. The approaches being developed involve studies of the membrane proteins at the biochemical level and of the corresponding genes by use of recombinant DNA techniques. The universal chromophore in all photoreceptors, vertebrate and invertebrate, is 11=cis-cis- retinal. The chromophore being the same, the chemical problem is to understand the nature of the interactions between retinal and the different proteins. These interactions result in sensitivity to different wavelengths of the visual spectrum.

Another pigment which also uses retinal (all trans retinal) as the chromophore has been discovered recently. This pigment, which is located in the membrane of certain extremely halophilic bacteria, such as Halobacterium halobium, pumps protons from the inside to the outside of the cell. The electrochemical gradient thus generated is used by the cell to synthesize ATP: the latter serves as the source of metabolic energy. This pigment, called bacteriorhodopsin, served as a very attractive model for structure-function studies of the visual pigments.

The amino acid sequence of bacteriorhodopsin has been determined both by amino acid sequencing and gene sequencing. A secondary structure model that is consistent with the amino acid sequence and electron diffraction data has been proposed. The orientation of the protein within the membrane, the site of attachment of the chromophore and its orientation within the protein have been determined. Further studies have revealed that the protein and its proteolytic fragments will refold to native structure after complete denaturation.

Their current research is focussed on the mechanism of the proton pump. What path does the proton take in being translocated from the inside of the cell to the outside? Is there a channel or a proton tunnel or regions of peptide side chains that can conduct protons? There are certain predictions on the kinds of interactions between different amino acids that might occur or might be required for the function. They have undertaken specific amino acid replacements in the protein by using recombinant DNA methods. The gene for bacteriorhodopsin has been cloned and single or multiple nucleotide substitutions are made in the gene. The mutated genes are then allowed to produce mutant proteins by transforming Escherichia coli with suitably constructed plasmids containing the gene. The mutant proteins are isolated and are used to study photokinetics, resonance Rman and Fourier Transform Infra Red Spectra, proton pumping, and other biochemical properties.

Professor Christopher Walsh and Professor William Orme-Johnson have a joint group working on the biogenesis of natural gas. The global biosynthesis of methane is estimated to be about 10^{15} g/year, a number approximating the yearly refining capacity of the U.S. Steel Industry. Thus natural gas

biogenesis is one of the largest scale biochemical reactions on the planet. Methane is produced exclusively by anaerobic bacteria with such distinctive characteristics they have been termed archaebacteria. Methanogenic bacteria can live on CO_2 and H_2 alone and convert 90% of it to CH_4, in an eight electron redox process. In a collaborative effort the two laboratories are engaged in purification of the key enzymes in both H_2 oxidation and CO_2 reduction.

Two novel and central features of methanogen biochemistry are, first, the plethora of novel coenzymes and cofactors now being discovered involved in these redox sequences and second the fact that some of them contain nickel.

Among the new coenzymes is a carba analog of vitamin B_2(riboflavin), specifically a 5-deaza riboflavin with gmax at 420nm, termed F_{420}, the molecule responsible for the characteristic blue green fluorescence of methanogenic bacteria. They have determined that F_{420}, as a low potential redox agent, is a direct electron acceptor for the electrons removed in H_2 oxidation and have purified the responsible enzyme, a hydrogenase, to homogeneity. The dihydro F_{420} is then a useful general currency for electron transfer in methanogen metabolism and may provide redox equivalents in reduction of CO_2 to CH_4.

The purified hydrogenase contains nickel in stoichiometric amounts in an as yet uncharacterized ligand environment. They have used Ni61 epr analyses to show that in enzyme as isolated the associated nickel is in the rare Ni^{III}-oxidation state but becomes reduced as enzyme is activated for H_2 reduction. They have obtained preliminary nickel EXAFS (extended x-ray absorption fine structure) spectral data for ligand analysis of the enzyme-bound nickel. Other H_2ases now seem to be nickel enzymes as well, so nickel-based enzyme hydrogenation catalysts may be quite common although not previously recognized until the past two years.

Organic

A major emphasis of current research in organic chemistry centers about the total synthesis of important natural products including macrolides (Masamune), carbohydrates (Masamune, Sharpless, Roush), alkaloids (Büchi), toxins (Büchi, Danheiser, Roush), peptides (Kemp), various natural products with antibiotics or antitumor activity (Büchi, Masamune, Berchtold, Danheiser, Roush), and intermediates in the biosynthesis of aromatic substances (Berchtold). Inherent in these total synthesis investigations are the development of new reagents (organic and inorganic) to effect specific synthetic transformations and emphasis on control of stereochemistry. Frequently the strategies developed for synthesis of certain natural products, such as antitumor agents, provide for structural modification in a search for related structures that may have more potent biological activity than that observed with the natural product. Structural modification of biosynthetic intermediates is also under study since certain structural changes may provide enzyme inhibitors that possess useful biological activity.

New procedures for asymmetric synthesis are being discovered (Sharpless) and, in collaborative efforts (Sharpless and Masamune), extensions of these studies with new reactions for control of stereochemistry in acyclic systems are resulting in unique syntheses of optically pure carbohydrates and related structures. Studies in peptide synthesis (Kemp) include the discovery of novel reagents to link peptide fragments of high molecular weight and the sythesis of important peptide hormones through the utilization of novel protecting groups. Important general strategies for the construction of carbocyclic systems in a single step with control of stereochemistry of the substituents are under investigation (Danheiser, Roush).

Investigations of the properties of unusual molecules and the mechanisms of their chemical reactions are under study in several laboratories. Modern cryogenic techniques are being applied to investigate the behavior of numerous reactive species which have been postulated as reaction intermediates (Masamune). These species are now directly observable, and energy surfaces of a certain system can be defined with a high degree of confidence. Currently under investigation are the small ring and multiple bond systems solely consisting of the main group IVA elements other than carbon.

Cycloaddition reactions may take place by a variety of mechanism, and recent investigations (Greene) strongly implicate an unexpected three-center process for certain cycloaddition reactions. Detailed investigations concerning the nature of transient intermediates in such reactions and the relationship between multiple-bond reagents and single-bond reagents in reactions with olefins and acetylenes are under investigation.

Arene oxides are interesting aromatic derivatives, and they have been demonstrated to be the initial intermediate in many biological hydroxylation reactions of aromatic substrates in plants and mammals. The mechanism of aromatization of arene oxides can follow a variety of pathways depending on the substituents present. Detailed investigations of the mechanism of aromatization of arene oxides are under study (Berchtold), and results are being compared with results observed in biological hydroxylation of aromatic substrates.

Inorganic

Research in inorganic chemistry includes efforts in organometallic synthesis, catalysis, photochemistry and energy conversion, bioinorganic chemistry, and main group chemistry.

Alan Davison's research group is involved in studies of the coordination chemistry of Tc, an element that is the basis of imaging in medical diagnostic procedures. Ligand synthesis, coordination chemistry, and animal testing of new imaging agents are included in Davison's program. Inorganic chemistry in medicine is also strongly represented in the research of the newest faculty member, Stephen Lippard. Lippard is actively engaged in understanding the action of the drug cis-$PtCl_2(NH_3)_2$ successfully used in combination chemotherapy for testicular cancer. Lippard's efforts, like those of Davison, include substantive collaborations with other research groups.

X-ray crystal structure determination, from the interests of Lippard, are now possible in-house at MIT for the first time in a decade. This should prove useful to the entire department, but especially to Richard Schrock whose research involves the synthesis of unusual organometallic substances of importance in catalysis. In recent years a plethora of interesting new molecules have come from the laboratory of Schrock, and they have been useful as new catalysts for olefin reactions including alkene polymerization and metathesis and acetylene metathesis. Detailed mechanistic understanding has also come from the study of the organometallics synthesized by Schrock.

Novel organometallic and main group chemistry is being pursued in the laboratory of Dietmar Seyferth. Clusters of main group and transition metal atoms is one current focus that will also be supported by facilities for X-ray crystallography. A new interest of Seyferth's is in the use of new main group molecules as precursors to ceramic materials such as silicon nitride.

Photochemistry of organometallic molecules in solution and on surfaces and semiconductor photoelectrochemistry are the central research interests of Mark Wrighton and his research group. Studies in the area of organometallic photochemistry have been useful in correlating electronic structure with reactivity and in elucidating catalytic reaction mechanisms. In the area of photoelectrochemistry, the long term aim is to convert optical energy to chemical and/or electrical energy.

As the short descriptions illustrate, inorganic chemistry at MIT comprises a wide range of fundamental activities of basic significance. At the same time, the research activities impact future chemical technologies. These qualities and the interdisciplinary interactions common in all of the groups provides a unique educational experience for the research students, while making the overall effort one of importance to the advancement of inorganic chemistry as a practical and scientific endeavor.

Physical

For some time physical chemistry has been a particularly strong research area at MIT. In part this owes to the vigor of the entire field, which has benefited from major advances occurring in instrumentation and in related fields of physics. Moreover, the techniques of physical chemistry have proven effective in answering questions that are of substantial significance to other disciplines, and to other areas of chemistry.

Research in physical chemistry at MIT balances experimental and theoretical aspects of the discipline. Of the ten current faculty, three are primarily experimentalists. Among the research areas actively being pursued are:

- Laser chemistry, photochemistry and spectroscopy (gas phase and molecular beams);
- Surface chemistry and catalysis;
- Solid state NMR;
- Dynamics of condensed phases (solids, fluids, polymers, critical phenomenon);
- Fundamental quantum mechanics and statistical mechanics;
- Thermodynamics of hydrocarbons

These areas are all at the forefront of progress in the chemical sciences.
Other areas in the chemistry department also contain research programs that qualify as first-rate physical chemistry. Noteworthy among these are excellent spectroscopic and electrochemical investigations by the Wrighton group in inorganic chemistry, NMR and EPR spectroscopy of biological species by Roberts and Orme-Johnson, and X-ray crystallography of proteins by the Petsko group. Strong ties between the physical chemists and others is not limited to these individuals nor to the chemistry department. There is active participation in collaborative efforts with the departments of physics, materials science, and electrical engineering, as well as the Spectroscopy Laboratory, the Research Laboratory for Electronics, the Center for Materials Science and Engineering, the National Magnet Laboratory, and Lincoln Laboratory.

CHRISTOPHER T. WALSH

Department of Earth and Planetary Sciences

On July 1, 1983, the Department of Earth and Planetary Sciences will merge with the Department of Meteorology and Physical Oceanography to form a new Department called Earth, Atmospheric, and Planetary Sciences. Present members of Meteorology and Physical Oceanography may decide to join a Center for Meteorology and Physical Oceanography which will exist within the new Department. The Center will serve to focus attention on the Atmospheric Sciences and related studies in Physical Oceanography. The Director of the Center will be Professor Peter Stone, and Chairman of the merged Department will be Professor William F. Brace.

The Earth Resources Laboratory, directed by Professor M. Nafi Toksöz, has become a major new research and teaching center within the Department of Earth and Planetary Sciences. Some 15 graduate and 10 undergraduate students are involved, working alongside postdoctoral fellows and research associates on a number of fundamental seismological problems, and on new methods of oil and gas exploration. A major effort this year was devoted to developing techniques of full wave acoustic logging and of vertical seismic profiling. Support for the Laboratory is approximately half industry and half government.

FACULTY

Professor Irwin Shapiro began a leave of absence in January, 1983, to become Professor at Harvard University and Director of the Smithsonian Astrophysical Observatory. Professor John Sclater will resign in September, 1983, to become Professor at the University of Texas at Austin. Three new Assistant Professors will join the faculty on July 1, 1983; Dr. David Jewitt, an optical astronomer, Dr. Brian Evans, an experimental geophysicist, and Dr. Kip Hodges, a structural geologist. Dr. Linda French will be appointed full-time instructor in astronomy on September 1, 1983. Professor Claude Allegre of the University of Paris was appointed Visiting Professor, a post which he hopes to occupy for two months every year starting March, 1983. On July 1, 1983, Professors Peter Molnar and Sean Solomon will be promoted to Full Professorship, Professor Edward Boyle will receive tenure, Professors Frank Spear and Charles Eriksen will become Associate Professors, Dr. Nobu Shimizu will become Senior Research Scientist, and Dr. Arthur Cheng will be appointed Principal Research Scientist. Professor Hubert Barnes of Pennsylvania State University was Crosby Visiting Lecturer during the spring term.

Honors

Professor Stanley Hart was elected to the National Academy of Sciences. Professor Charles Counselman will receive the Carl Pulfrich Prize awarded by Carl Zeiss, Inc., in August, 1983.

ENROLLMENT

Graduate enrollment remained nearly constant, with about 80 students at MIT and 40 enrolled in the Joint Program at WHOI. The undergraduate enrollment remained nearly constant at 37. The majority of the majors will enter graduate school. The field camp held annually during IAP was unusually successful. Some 51 people participated in combined geologic and geophysical field studies in the Las Vegas area, under the direction of Professors Burchfiel, Madden and Molnar. Eight students from Wellesley participated, as part of MIT's cooperative arrangement with that College.

RESEARCH

Geology

Professor Clark Burchfiel and his students are currently studying the tectonics of northern Norway, southern Nevada, and central British Columbia. One highlight of their work was the discovery of extensive low-angle normal faults extending deep into the crust beneath the Basin and Range of Nevada. Entirely new tectonic models and mechanical hypotheses are necessary to explain these unsuspected features.

Professor Roger Burns has discovered substantial concentrations of ferric iron in several fayalites occurring worldwide in alkaline igneous rocks. It is unusual for the olivine structure to accommodate trivalent cations. These observations complement the discovery of ferrifayalite (laihunite) in high grade metamorphic rocks described recently in China.

Professor Fred Frey presented a new model for the origin of Hawaiian tholeiitic and alkalic basalt, which represents a significant advance in our understanding of intra-oceanic plate volcanism. He has also

found important differences with Hawaiian volcanoes and those associated with the Chilean convergence zone.

Professor Tim Grove's petrologic studies indicate that calc-alkaline lavas develop from basaltic primary magmas by crystallization under crustal conditions. His study of the Medicine Lake volcano in California has shown that magma mixing and assimilation of continental crust have accompanied crystallization in producing the calc-alkaline series lavas found there. The results imply that andesites are not primary melts of subducted oceanic crust or hydrated mantle peridotite, as is widely thought, but are products of fractional crystallization under crustal conditions.

Professor Frank Spear has developed a technique used to decipher the pressure-temperature evolution of rocks, from a thermodynamic analysis of compositional zoning in minerals such as garnet. Applications to terranes in New England and in the Alps reveal that many samples crystallize during marked decompression, often with increasing temperature. These P-T paths are in striking contrast with the regional metamorphic gradient, which generally shows a gradual increase in T and F.

Professor Stanley Hart has completed a Sr-Nd-Pb isotopic study of the ultramafic rocks from St. Paul's Rocks - a locality unique in being the only exposed occurrence of ultramafic rocks in the oceans. The Sr-Nd-Pb isotopic patterns are identical to alkali basalts from many of the volcanic islands in the Atlantic; St. Paul's Rocks is thus the first documented surface exposure of mantle material capable of supplying alkali basalts during partial melting.

Geophysics

Professor Keiiti Aki has developed a so-called "barrier model" for simulating the strong ground acceleration generated by earthquake faulting. This model has been very useful in unifying a variety of historical, geological and seismological observations on earthquakes, including their recurrence behavior.

In his core motion studies, Professor Theodore Madden can now distinguish between convected features (westward drift) and wave propagation phenomena by examining the time variations of the velocities inferred. The large relative variations in velocity seem to rule out a wave propagation effect since the time span is too short to have allowed much change in the core properties, which changes are needed to alter the wave velocities. Thus, the apparent westward drift of the magnetic fields may be due to a real westward drift and the convective motions which drive the drift are quite variable on a decade time scale.

From modelling the gravity field in northern California, Professor Marcia McNutt has found evidence for significant lateral heterogeneity in the North American plate caused by subcrustal erosion of up to 80 percent of the lithosphere along the west coast by the subducting Gorda plate. Using the new SEABEAM technology for precisely mapping broad bands of the seafloor from a surface ship, she has identified distinct episodes of undersea volcanism on small Tertiary seamounts and dated them, using their paleomagnetic fields. The results indicate that although most of these volcanoes originate near midocean spreading ridges, they continue to be episodically active for many millions of years.

Professor Peter Molnar has begun a field investigation of active faulting in China in collaboration with geologists from the People's Republic of China. One of the first results is that if one combines the displacements that took place during great earthquakes in Asia since 1900, the combined effect is an east-southeastward displacement of southeast China with respect to Siberia at the average rate of about 2 cm/yr. This corroborates the inference that India's collision with and penetration into Asia is rapidly squeezing China out of its way.

Professor Barry Parsons has found a good correlation between depth and geoid anomalies; in particular, mid-ocean swells such as the Bermuda Rise are associated with positive depth and geoid anomalies with wave-lengths around 2500 km. Related theoretical work suggests that these anomalies primarily reflect temperature variations within the upper thermal boundary layer of convection occurring beneath the oceanic lithosphere.

Professor John Sclater and colleagues have developed a two-layer model for stretching of continental lithosphere that attempts to take account of the different rheological properties of the continental crust and subcrustal lithosphere. This model has been successful in predicting uplift and erosion in the flanks of grabens during extension. The model has been applied to the North Sea and is currently being applied to basins in China.

Professor Gene Simmons has shown that granites contain healed microcracks, that rare earth elements are mobile and have migrated in the geologic past, and that microcracks have provided the pathways for the migration of uranium. Similar studies of microcracks have potential for predicting the extent of migration over geologic time of radioactive isotopes from waste repositories in crystalline rocks.

Professor Sean Solomon has used networks of ocean-bottom seismometers to locate microearthquakes below the seafloor with unprecedented accuracy. He found that microearthquakes on a major oceanic transform do not become more shallow as the rise intersection is approached, contrary to predictions from standard thermal models, and that there is well-resolved microearthquake activity to mantle depths directly beneath the median valley of a segment of the Mid-Atlantic Ridge. Both results point to the significant influence of hydrothermal circulation on the shallow thermal structure of oceanic lithosphere.

Professor Nafi Toksöz supervises a network of seismic stations to monitor the northeastern U.S. and better understand the nature of earthquakes in New England. Their mechanisms and ground motions are different from those of earthquakes in California. These new results are leading to new engineering design criteria for New England.

Planetary Science

Professor Charles Counselman has developed an inexpensive, portable, geodetic instrument that can determine all three position coordinates of a point on the ground within less than one-millionth of the distance to a reference point. The instrument uses radio signals from earth satellites, and works in any weather. This development makes it practical, for the first time, to map the three-dimensional deformation of the earth's crust throughout a region of tectonic activity.

Professor James Elliot has developed a method for studying the kilometer scale structure of the Uranian rings through least squares fitting of a diffraction model. Using this method to analyze ring occultation data obtained this spring, they find that Ring 5 has a variable width. Their method also yields angular diameters of the stars occulted by the rings to an accuracy of a few percent. This establishes ring occultations as the most precise method for obtaining stellar diameters less than a few milliseconds of arc.

Professor Gordon Pettengill has combined radar scattering and radio emission data to obtain an estimate of 27 ± 7 for the dielectric constant of several regions on the surface of Venus. This unusually high value implies that 10 percent of the surface rock in these regions consists of electrically conducting material, probably iron pyrites.

Professor John Southard has been able to simulate sediment transport on the surface of Venus. Results, using lightweight sediment to satisfy the requirement that the ratio of sediment density to gas density be the same on Venus and in the model, and with wind velocity adjusted appropriately in accordance with the model, show that wind velocities thought to be present on Venus are indeed adequate to move sediment. Movement involves more near-bed traction and less saltation than on Earth, and no wind ripples or dunes developed.

Oceanography

Professor Edward Boyle has shown that North Atlantic deep water flow is controlled in part by changes in the tilt of the Earth's axis. His group has used fossil chemistry to place limits on long-term seafloor spreading rate variations and to study the historical anthropogenic lead input to the ocean.

Professor John Edmond finished a study of the geochemical cycle of beryllium-9, the stable isotope of the element. The results have an important bearing on the use of the cosmic ray produced radio-isotope Be-10 as a geochronometer. The feasibility of detection of this isotope by accelerator methods has opened up a major time "window" not available to conventional radio-isotopes and of great potential for dating events over the last 15 million years.

Professor Charles Eriksen has shown that variations in the trade winds in the western Pacific generate equatorially-trapped baroclinic Kelvin waves in the ocean which travel eastward at 2-3 m/s. These waves are a key mechanism in the adjustment of the tropical ocean to changes in wind forcing since they traverse the Pacific basin from west to east in a month or two, making possible the rapid widespread warmings of the upper ocean known as El Nino events. He is now studying changes in the deep ocean linked to the 1982 El Nino, the most intense such event of this century.

Professor Carl Wunsch has continued to explore the new observational tool, satellite altimetry, for the understanding of the large-scale ocean circulation. Using the data from SEASAT, they have produced the first global charts - made totally independently of shipboard observations - of ocean dynamic topography. Such instruments could revolutionize the study of the ocean.

WILLIAM F. BRACE

Department of Mathematics

During the 1982-83 year there were 193 undergraduates and 114 graduates majoring in Mathematics. The Bachelor of Science was awarded to 58 students, including 12 double majors. There were five recipients of the Master of Science and 21 recipients of the Doctor of Philosophy in Mathematics.

UNDERGRADUATE PROGRAM

In calculus, the system of repeatable examinations continues for just the basic year sequence 18.01-18.02, i.e., for those students with little prior exposure to calculus. Reverting partially to a system prevalent here 30 years ago, students were asked this year to show evidence at each recitation of having done the appropriate homework. Though not exactly popular, this plan was nonetheless strongly approved by the students at the end of the year as having helped them stay abreast of the material, and they recommended its continuation for the generations to come.

The traditional large-enrollment upper-level service course in mathematics has for many years been the year-long Advanced Calculus sequence. However, the rise in the number of majors in Electrical Engineering and Computer Science, a department with relatively high mathematics requirements, has led to a corresponding increase in enrollments in several upper-level mathematics courses that now equal the Advanced Calculus enrollment: Linear Algebra (18.700), Complex Variables (18.04), and Introduction to Algebraic Systems (18.063), all of which have around 200 or more students each semester they are offered.

With the advent of Project Athena, it is expected that individual faculty members will be devoting some time during the coming year to considering the impact of the IBM Personal Computers on mathematics courses, adapting, designing, and testing material, probably mostly in the relevant upper-level courses to start with.

FACULTY

Isadore M. Singer, formerly a professor at the University of California at Berkeley and at M.I.T., has been appointed as the first John D. MacArthur Professor of Mathematics.

Professor Arthur P. Mattuck was renamed Class of 1922 Professor for a third five-year term. He is the only faculty member holding this chair who has ever had his term renewed.

Assistant Professors Sy D. Friedman, Ravindran Kannan, and Michael Sipser were promoted to the rank of Associate Professor. Dr. William M. Goldman, a C.L.E. Moore Instructor, was appointed Assistant Professor.

A National Science Foundation (NSF) Postdoctoral Fellowship was held by Dr. Devra Garfinkle, Instructor; Bantrell Fellowships were held by Assistant Professor F. Thomson Leighton and Dr. Marius Ungarish, Applied Mathematics Instructor.

Professor Victor W. Guillemin will succeed Professor Michael Artin as Chairman of the Pure Mathematics Committee. Professor David J. Benney will succeed Professor Harvey P. Greenspan as Chairman of the Applied Mathematics Committee. Professor Nesmith C. Ankeny will continue as Chairman of the Graduate Committee.

Professor Leighton is author of a forthcoming book, Complexity Issues in VLSI (MIT Press).

The following faculty were on leave during the year: Professors Louis N. Howard (Florida State University), Steven L. Kleiman (Mathematics Institute, University of Copenhagen), Bertram Kostant (Institut des Hautes Etudes Scientifiques and University of Paris), Franklin P. Peterson and Daniel G. Quillen (Mathematical Institute, Oxford University); Assistant Professors Jeffry N. Kahn (Rutgers University), Frank Morgan (Rice University), and Rodolfo Rosales and Gunther Uhlmann (University of California, Berkeley).

Visitors

The following mathematicians visited during the year: Professor Kenneth Baclawski (Haverford College), Professor Olga Beaver (Williams College), Dr. Henri Berestycki (University of Paris), Professor Charles Cadogan (University of the West Indies), Dr. Eduardo Cantoral (University of Puebla, Mexico), Professor

Larry Gillick (Northeastern University), Dr. Allan Greenleaf (NSF Postdoctoral Fellow), Professor Arnold Grudin (Dennison University), Professor David Harbater (NSF Postdoctoral Fellow, University of Pennsylvania), Professor Melvin Hochster (Guggenheim Fellow, University of Michigan), Dr. Lu-Min Jiang (People's Republic of China (PRC)), Professor Ko-Wei Lih (Taiwan), Dr. Daniel Meiron (Bantrell Fellow, California Institute of Technology), Dr. Louis Santharoubane (University of Paris), Dr. Ji-Ching Sha (PRC), Dr. Alex Uribe (Postdoctoral Fellow, National University of Mexico).

HONORS

In a recently announced ranking of mathematics departments, this Department was tied for top rating with Princeton University and the University of California at Berkeley. The "quality of graduate program" was, however, only tied for second, after Princeton.

A number of mathematics faculty were recognized for distinguished scholarship by being elected to membership in several highly selective American and foreign honorary societies. Professor Alar Toomre was elected to membership in the National Academy of Arts and Sciences. Professors Guillemin and Harold M. Stark were elected to membership in the American Academy of Arts and Sciences. Professor Daniel M. Kan was elected to membership in the Royal Dutch Academy of Sciences. Professor George Lusztig, who currently holds a Guggenheim Fellowship, was elected to membership in the Royal Society.

Professor Richard Stanley was awarded a Guggenheim Fellowship. Professors Greenspan and Gerald E. Sacks were both awarded Fairchild Fellowships and will spend part or all of next year at California Institute of Technology.

Professor Herman Chernoff was awarded an honorary Doctor of Science from Ohio State University. Some former students and colleagues organized a Festschrift in honor of his sixtieth birthday. The volume of collected papers was presented to him at a special ceremony at Stanford University on July 1, 1983.

DANIEL J. KLEITMAN

Department of Meteorology and Physical Oceanography

On March 21, 1983, the Department of Meteorology and Physical Oceanography (MPO), together with the American Meteorological Society, sponsored a one-day celebration of the life of the late Professor Jule Charney, former Head of the Department. The celebration, which was attended by over 200 atmospheric scientists from all over the world, featured presentations by a number of Charney's colleagues describing his profound influence on modern meteorology and physical oceanography.

Richard S. Lindzen accepted an appointment as Professor of Meteorology, to become effective July 1, 1983. He will hold the Alfred P. Sloan chair, formerly held by Charney. Lindzen, who is well known for his work in atmospheric dynamics, comes from Harvard, where he was Robert P. Burden Professor of Dynamic Meteorology. He is the recipient of the Macelwane Award of the American Geophysical Union and the Meisinger Award of the American Meteorological Society, and is a member of the National Academy of Science.

Randall Dole accepted an appointment as Assistant Professor of Meteorology, to become effective July 1, 1983. A Ph.D. graduate of the Department, he is known for his diagnostic studies of atmospheric blocking situations.

Two of the Department's young physical oceanographers received promotions during the year. Mark Cane, who is known particularly for his theoretical work on the tropical oceans and equatorial currents, was promoted to Associate Professor. Glenn Flierl, who is well known for his contributions to the theory of solitary waves, was promoted to Associate Professor with tenure.

The Department was saddened by the death of Delbar Keily, Associate Professor of Meteorology, Emeritus, on June 16, 1982. Keily was a specialist in the field of aircraft and meteorological instrumentation. Raymond Pierrehumbert resigned his position as Assistant Professor of Meteorology, to take a position at the National Oceanic and Atmospheric Administration's (NOAA's) Geophysical Fluid Dynamics Laboratory in Princeton, NJ. John Evans, Director of Haystack Observatory, Professor of Meteorology, and Assistant Director of Lincoln Laboratory, resigned his posts to become Director of Research at COMSAT Labs in Gaithersburg, MD.

Visitors to the Department during the past year included Dr. Mai-Tsun Li, Director of the Laboratory for General Circulation and Long-Range Forecasting, Institute of Atmospheric Physics, Academia Sinica, Beijing, People's Republic of China, and Dr. Gilles Reverdin of the Laboratoire d'Oceanographie Physique, Museum National d'Histoire Naturelle, Paris, France.

Professor Edward Lorenz was co-recipient of the prestigious Crafoord Prize of the Swedish Academy of Sciences for "fundamental contributions in the field of geophysical hydrodynamics." The other recipient was Dr. Henry Stommel, a former member of the Department who is now at the Woods Hole Oceanographic Institute. This was the first time the Crafoord prize has been awarded in the fields represented by the Department. Lorenz also received an honorary Doctor of Science degree from McGill University.

During the year the Department and the Department of Earth and Planetary Sciences (EPS) agreed to merge to form a single new Department, to be called Earth, Atmospheric, and Planetary Sciences. The new Department will contain a Center for Meteorology and Physical Oceanography. W.F. Brace, present Head of EPS, will become Head of the new Department, and Peter Stone, present Head of MPO, will be the Director of the new Center. The merger will become effective on July 1, 1983.

RESEARCH

Professor Mark Cane has developed an extremely fast filtered numerical model to study low-frequency motions of equatorial oceans. The model has been used to study El Niño. Results support the remote forcing theory for the second warming, but raise serious doubts about its applicability to the warming which initiates the El Niño sequence.

Professor Kerry Emanuel developed a Lagrangian parcel theory for moist convection resulting from accumulated gravitational and centrifugal potential energy in the atmosphere. The theory accounts for many nonlinear aspects of the convection, and suggests a simple but comprehensive means by which the potential for instability may be assessed using routine soundings of the atmosphere.

Professor J.V. Evans and his associates at the Millstone Hill radar continued their program of radar investigations of the structure and dynamics of the middle and upper atmosphere. In April/May 1983, a program of radar/balloon measurements of the turbulence altitude profile was conducted in cooperation with the Air Force Geophysics Laboratory.

Professor Glenn Flierl theoretically derived general conditions under which strong vortices can be considered as isolated. He has shown that rings not only propagate as strongly nonlinear waves but also radiate energy in the form of Rossby waves in the deep ocean. These waves not only will cause a spin-down of the eddy but also will exert forces on the pool of warm water which can force a southward motion. Flierl has also been studying biological populations associated with Gulf Stream rings. He has demonstrated that there is a critical range of ring motion speeds relative to the mean flow in which the ring sweeps a large proportion of the fish larvae off the continental shelf and significantly reduces the population stock.

Professor D.E. Harrison has completed a study of the way tropical ocean surface temperature changes in response to remote wind events and has used the results of this study to offer an explanation for the initial stage of warming that occurs in El Niño events in the Pacific Ocean. These ideas appear to explain the onset of both the "normal" El Niño events and the anomalous 1982 event. He has also completed a study of the wind driven ocean circulation in middle latitudes which shows that the behavior of model Gulf Stream-like currents can be understood only when the gyre scale circulation is treated as a coupled system, not independently as has been done previously.

Professor E.N. Lorenz analyzed a new mathematical analog of the climate system. The analog differs from previous ones in that its "attractor" consists of an infinite complex of three-dimensional manifolds, not approximated by any small set of manifolds. The states realized by the analog during its evolution are not strongly limited by the restrictions imposed by the attractor, in contrast to earlier analogs, which were strongly limited. Lorenz believes that more realistic atmospheric models will have a behavior lying between these two extremes.

Professor Erik Mollo-Christensen, working in collaboration with Dr. S. Worthem and Dr. F. Ostapoff of NOAA, Miami, on processes in the equatorial ocean, has found that the Earth's rotation makes possible unstable progressive waves generated by an instability of the salt and thermal stratification. This provides a mechanism for transport of heat and salt in the region of the equatorial undercurrent, and the results of their analysis are proving helpful in interpreting their recent observations of velocity and density structure in the equatorial Pacific.

Professor Reginald E. Newell and his collaborators have continued their studies of the Southern Oscillation with an analysis of a 100-year set of ships' reports from the Pacific together with other data. The Southern Oscillation was found to appear first as changes in the subtropical oceanic gyres, then in the equatorial upwelling, tropical tropospheric winds, western Pacific rainfall, and tropical tropospheric air temperature. From a separate set of wind data in the free troposphere the linkage between low and middle latitudes, which forms part of the same phenomenon, has been found to be much stronger in northern-hemisphere winter.

Professor Richard Passarelli and his collaborators are conducting intensive field observations and analyses aimed at understanding the mesoscale phenomena of New England winter storms and coastal fronts. During the first field season (December 1982-January 1983), an instrumented aircraft (supplied by the National Center for Atmospheric Research) and a radiosonde balloon system (supplied by the National Aeronautics and Space Administration) were used in conjunction with the MIT Doppler radar to collect data during winter storm events. Analysis of the aircraft observations has shown that the front itself resembles a density current similar to a land breeze.

Three years of data from a globally-distributed network of measurement stations have enabled Professor Ronald Prinn and his collaborators to determine the rates of increase and the atmospheric lifetimes of several chemicals important in the ozone layer. The compounds $CFCl_3$, CF_2Cl_2, CH_3CCl_3, CCl_4, and N_2O are presently increasing over the globe at rates of 6, 6, 9, 2, and 0.2 percent per year respectively. The derived lifetimes of $CFCl_3$ and CF_2Cl_2 are so long that the only important destruction mechanism for these two fluorocarbons is photodissociation in the stratosphere. The CH_3CCl_3 data have enabled an accurate indirect determination of the globally averaged concentration of the atmospheric OH radical; this radical is one of the most important species in the chemistry of the troposphere.

Professor Paola Malanotte Rizzoli has been using theoretical solutions for coherent structures to model highly nonlinear, energetic, localized features observed in the atmosphere and the ocean. In the atmosphere, one such theoretical structure has been used to explain some of the observed features of atmospheric blocking. In the ocean, the specific mechanism of boundary forcing and its capability to radiate highly nonlinear eddies has been studied as an idealized model for the shedding of Gulf Stream eddies.

Professor Frederick Sanders studied the narrow band of heavy snow that occurred on 11-12 February 1983 and extended from Washington, DC, through Boston. Doppler radar measurements from the MIT Weather Radar Project disclosed a snow-generating updraft in a narrow layer of air moving rapidly northward above northeasterly winds near the surface. Balloon measurements from MIT indicated the presence, in this layer, of instability to gently sloping motions, resulting from a combination of buoyancy and vertical effects as eludidated theoretically by Professor Emanuel. This instability was present along the path of the storm from the mid-Atlantic states to Nova Scotia, and was evidently responsible for the banded concentration of the snow.

Professor Peter Stone and his collaborators have carried out the first calculations showing the quantitative effect of feedbacks associated with atmospheric motions on climate sensitivity. Both the vertical and meridional transports of heat associated with atmospheric motions supply a strong negative feedback to global temperature changes induced by changes in solar constant or in atmospheric carbon dioxide content. Without these feedbacks the temperature changes would be about four times larger. This result demonstrates the importance of simulating dynamical feedbacks accurately in climate calculations.

PETER H. STONE

Department of Nutrition and Food Science

EDUCATIONAL ACTIVITIES

Graduate Degree Programs

Graduate degrees (S.M., Ph.D., or Sc.D.) are currently awarded in five areas of specialization: nutritional biochemistry and metabolism, neural and endocrine regulation, food science and technology, biochemical engineering, and toxicology.

Significant developments have taken place with respect to the food science/biochemical engineering area, in that the framework of a new graduate program in Biotechnology has been formulated which represents coalescence of certain elements of the two existing degree areas. The new program will involve three disciplinary areas: microbiology/genetics, biochemistry/chemistry, and chemical engineering/biochemical engineering. The objective will be to prepare students for careers that apply modern biology, biochemistry, and engineering to problems in the production of chemicals, foods, and medicinal agents. Core courses are being developed that will deal with biological transformation, bioreactor design, and product isolation and recovery. The first of these courses was offered in the 1982-83 academic year, and it is anticipated that the curriculum will further expand within the next academic year. These core courses will be supplemented by additional subjects appropriate to the backgrounds and research projects of students in the program. In addition, discussions have been initiated with faculty members in the Departments of Biology, Chemistry and Chemical Engineering concerning the development of an interdepartmental degree program in Biotechnology of which the departmental curriculum would be a component.

With a growing awareness by the health professions that the application of nutritional principles is essential for prevention, diagnosis, and treatment of human diseases and in the formation of lifestyles that promote optimal health within complex environments, the Department has continued to develop and offer scholarly, advanced training for students concerned with careers in nutrition. The teaching and research programs in nutrition are based on the principles of biochemistry and physiology, with particular reference to metabolic regulation. The common thread throughout the program is the study of relationships between dietary factors and mammalian metabolism. Such studies require an understanding of all levels of metabolic organization, ranging from subcellular to whole body, including extensive use of human and non-human experimental models. In order to meet these objectives, students in the curriculum acquire competence in the fundamentals of biochemistry, physiology, intermediary and protein metabolism and its regulation, and in basic and human nutrition. Opportunities are then provided for specialization as resources and faculty expertise permit.

During the 1982-83 academic year, a total of 164 graduate students were enrolled as degree candidates in S.M. or Ph.D. programs. Doctoral degrees were awarded to 29 students, and S.M. degrees to 30.

Undergraduate Programs

Enrollment in the undergraduate program in Applied Biology (Course 7B) in the 1982-83 academic year was 39 students. Faculty and staff participated in other undergraduate activities as freshman advisors (11) and as advisors for premedical students (5). The department also encouraged substantial involvement in the UROP program. During the 1982-83 year, research projects involved an average of 19 faculty and 40 students in each of the summer, fall, and spring terms.

CONFERENCES AND SYMPOSIA

On September 22, 1982, the Department sponsored the Twentieth Annual Underwood-Prescott Symposium, entitled "Enzymes as Industrial Catalysts in the Food and Pharmaceutical Industries." Professor Ephraim Katchalski-Katzir, Institute Professor at the Weizman Institute of Science, and former President of Israel, was the recipient of the award. He was chosen for his pioneering work in the preparation and application of immobilized enzymes which has had tremendous impact on the food, biochemical and pharmaceutical industries. Professor Katzir's lecture concerned enzyme processes in biotechnology.

Dr. Richard I. Mateles, Vice President of Research at Stauffer Chemical Company, and Professor Klaus Mosbach, Professor of Pure and Applied Biochemistry, University of Lund, Sweden, were the other participants. Dr. Mateles presented a lecture entitled "An Economic View of Enzymes" and Professor Mosbach discussed second generation enzyme technology.

The Mayer Lecture, an annual event which rotates sponsorship among this department, the Department of Biology, and the Biology Department at Wellesley College, was held November 10, 1982. This year's

distinguished lecturer was Professor J. Denis McGarry, Professor of Internal Medicine and Biochemistry at the University of Texas Health Sciences Center in Dallas. The lecture, attended by numerous members of the MIT and greater Boston scientific community, was entitled "Regulation of Liver Metabolism during Feeding and Fasting-The Glucose Paradox."

In conjunction with the Industrial Liaison Program, Dr. Robert Langer, associate professor of Biochemical Engineering, directed a one-week course in Brussels, Belgium, in May, 1983, on "Controlled Release Technology: Polymeric Delivery Systems for Drugs, Pesticides, and Foods." Topics that were discussed included: fundamental principles of controlled drug release; bioerodible polymers and drug-targetting approaches; recent advances in controlled release; and fabrication technology and microencapsulation.

Dr. Arnold L. Demain, professor of Industrial Microbiology, participated in a series of public lectures at Moorhead State University entitled "The Genetics Revolution," where he discussed the impact of genetics on industrial microbiology.

FACULTY

Dr. R. Alan North, associate professor of Neuropharmacology, was awarded tenure effective July 1, 1983. Dr. James G. Fox was promoted from associate professor of Laboratory Animal Medicine to full professor. Dr. Alexander M. Klibanov, assistant professor of Applied Biological Sciences, was promoted to associate professor effective July 1, 1983.

Resignations of two faculty members were effective during this academic year. Dr. Barbara Underwood, formerly associate professor of Nutrition, accepted a position as program director in the National Eye Institute at NIH. Dr. John Fernstrom left MIT to become associate professor of Psychiatry and Pharmacology at the Western Psychiatric Institute and Clinic of the University of Pittsburgh.

FACULTY AWARDS

A number of faculty were recipients of various awards and honors during the academic year. Dr. Robert S. Langer was appointed the Dorothy W. Poitras Professor in Medical Engineering jointly in the Department and in the MIT Whitaker College of Health Science, Technology, and Management. Dr. Michael F. Holick was this year's winner of the Mead Johnson Award for Research in Nutrition. This prestigious award administered by the American Institute of Nutrition recognizes an investigator under 40 years of age who has done outstanding research in nutrition. The citation recognizes Holick's combined skills as a nutritionist, biochemist, physiologist, and clinical investigator in achieving his highly imaginative research in chemistry, metabolism, and photobiology of vitamin D.

Dr. George Wolf was invited by the United States Academy of Sciences to be an Exchange Visitor to the Hungarian Academy. He visited the Hungarian Institute of Nutrition, Central Food Research Institute, National Institute of Oncology, and the Semmelweis University Medical School in Budapest.

GERALD N. WOGAN

Department of Physics

In the past year the Physics Department continued its traditional vigorous and dedicated attack on major research problems of contemporary physics as well as on the challenge it faces as a major component of the MIT educational program.

With regard to the latter, it has maintained a relatively constant credit units per faculty member as well as a relatively stable total of physics students, graduate and undergraduate, over the past 10 years. In this year the number of undergraduate majors was 249, and the number of graduate students was 296. The number of degrees awarded totaled 52 B.S., 9 M.S., and 33 Ph.D.

The large number of graduate students reflects the substantial research funding which the Physics Department faculty has continued to receive, mostly from the DOE, NSF, NASA, and the DOD. This has been particularly gratifying in view of the financial limitations which have been placed on these agencies with regard to the funding of basic research. The Department's research accomplishments are described in later parts of the report. Some of the major projects which have been completed in the past year or are in the development phase include (1) the energy doubler at the Bates Linear Accelerator, essentially ready for research use, (2) the optical telescope being constructed in collaboration with Dartmouth and the University of Michigan, (3) the construction of a major detector at the cost of $50 million at the LEP facility at CERN, one of the three which will be ready at the start up of LEP. This multi-national effort is under the leadership of Professor Samuel C.C. Ting, (4) the construction of a detector and the Brookhaven National Laboratory at their synchrotron light source in collaboration with IBM.

The members of the Physics Department continue to provide leadership for the major MIT interdepartmental laboratories. At the present moment the directors of the Laboratory for Nuclear Science, Bates Linear Accelerator, Center for Space Research, Center for Materials Science and Engineering, National Magnet Laboratory, Spectroscopy Laboratory, and Plasma Fusion Center are members of the Physics Department.

In 1982-83 the total number of faculty members was 92. The following members of the faculty received promotions during the year: to full professor: Robert L. Jaffe, John Joannopoulos, Paul C. Joss, Marc A. Kastner, and Ernest J. Moniz; to associate professor: James G. Branson. Patrick Lee, an international authority in theoretical condensed matter, was appointed as professor and will lead our group working in this area. Appointed as assistant professors were Edward H. Farhi and Ralph L. McNutt.

Visiting faculty during the year included Professors P.M. Mathews, Jeremiah Ostricker, and Anton Zeilinger.

Administrative appointments in Physics are as follows: Professor Jerome I. Friedman will become Department Head, succeeding Professor Herman Feshbach who recently was appointed Institute Professor; Professor Arthur K. Kerman will succeed Professor Friedman as Director of the Laboratory for Nuclear Science; Professor Jeffrey Goldstone will succeed Professor Kerman as Director of the Center for Theoretical Physics; Professor J. David Litster will become Director of the Center for Materials Science and Engineering, succeeding Professor Mildred Dresselhaus, and Professor Moniz will become Director of Bates Linear Accelerator, succeeding Professor Peter T. Demos. Professor Robert J. Birgeneau has become Associate Director of the Research Laboratory of Electronics and also has been named Cecil and Ida Green Professor of Physics.

The Department has continued to develop industrial connections through its workshops. Held in the fall of 1982, the second workshop focussed on frontiers in optics. The next workshop will deal with surface phenomena. The Department received for a second year a grant of $25,000 from IBM as part of its program for "seed money" awards to leading departments of physics.

Faculty Sloan Fellows include Professors Charles R. Alcock, A. Nihat Berker, Lennox Cowie, Alan Guth, Jaffe, Joss, and Scott Tremaine. This reflects the excellent quality of the younger members of our faculty recruited in the recent past. Also, Professor Jaffe (jointly with Professor Frank Solomon of Biology) received the MIT School of Science Prize for Excellence in Undergraduate Teaching, and Professor Tremaine received

the Helen B. Warner Prize of the American Astronomical Society. Additional prizes to our faculty were Humboldt Senior U.S. Scientist Awards to Institute Professors Feshbach and Victor F. Weisskopf.

In student affairs, it is significant to report that 114 students have been inducted into the MIT chapter of Sigma Pi Sigma, the physics honor society associated with the National Society of Physics Students, operated under the auspices of the American Institute of Physics. This year three physics students--Anthony D'Amico, Raymond Goldstein, and Steven Janowsky--were elected to Phi Beta Kappa. The Orloff Prize for physics seniors, an annual prize given by the parents of Joel M. Orloff, Class of 1978, in his memory, was awarded to Robert J. Lenk. The Apker Award of The American Physical Society went to Subir Sachdev, and the Deflores Prize, under the auspices of the Department of Mechanical Engineering, was awarded to James Colgate of Physics. Joanne Donovan, a physics Ph.D. candidate, was awarded the Student Research Prize by the American Gastroenterological Society.

Leaves of absence during the year included Professors W. Carlisle Barber, Hale V.D. Bradt, Harald Enge, Anthony P. French, Bernard T. Feld, Joss, Henry W. Kendall, and Edward Wright.

Resigning this year were Professors Shimon Levit, Margaret H. Weiler, and Wright.

Some points of concern should be mentioned. The principal problem which faces the Department is the low fraction of non-tenured faculty. This is a consequence of the absence of any statutory retirements for the last 10 years (there have been three early retirements). We project that the percentage of tenured faculty which is 82 percent this year will go to 90 percent in the next two years. The importance of young faculty for the health of the Department's research and educational programs cannot be stated too strongly, so we view this development with considerable alarm.

A second issue which needs to be mentioned is the dispersion of the Physics faculty over a wide area of the campus. In spite of this problem, it is a pleasure to report that there has been extensive collaboration among the condensed matter and the nuclear and particle theorists.

RESEARCH

Astrophysics

The analysis of X-ray emission from X-ray pulsars and bursters continues to be a valuable source of new knowledge about the properties of neutron stars and black holes, and about the evolution of the close binary systems in which these end products of stellar evolution are observed by virtue of the X-rays they emit as they accrete matter from their companion stars. The orbital elements of the binary X-ray pulsars LMC X-4 and 3S 1553-542 have recently been determined with high precision by analysis of archival SAS-3 data on the Doppler variation in their pulse frequencies. Studies of SAS-3 data on X-ray bursters have shown that the X-ray photospheric radius of a neutron star may increase substantially during an X-ray burst, a result that has stimulated new theoretical work on the mechanisms of non-equilibrium radiative transfer in a thermonuclear flash on the surface of a neutron star. Parallel with these and other observational studies of X-ray emitting close binary systems is an ongoing theoretical study which has elucidated the evolution of low-mass binaries with particular application to the interpretation of the phenomenology of cataclysmic variables and binary X-ray sources of Population II.

Steady progress has been achieved in the program of identification and study of the optical counterparts of X-ray sources whose positions have been determined with high accuracy by the modulation collimator experiment on the HEAO-1 satellite. Many candidate ultra-blue objects, located in the positional error boxes of the X-ray sources, have been found through detailed spectroscopic analysis to be distant Seyfert galaxies or quasars.

Continuing analysis of high-resolution X-ray spectroscopy data from the Einstein X-ray Observatory has demonstrated the existence of conditions of ionization disequilibrium in the Cygnus Loop and Tycho supernova remnants, and substantial abundance anomalies in Tycho and N132D, the latter being a supernova remnant in the Large Magellanic Cloud.

This and other results derived from the MIT Focal Plane Crystal Spectrometer on the Einstein Observatory have established high resolution X-ray spectroscopy as a powerful method of analysis of the composition and physical properties of ultra-hot plasmas encountered in galactic and extragalactic astronomy.

Evidence has been found of more optical counterparts of gamma-ray bursts in a comprehensive search of archival photographic plates. Meanwhile work is proceeding on development of an Explosive Transient Camera that is designed to record directly the optical flashes that may accompany gamma-ray bursts.

I. Theoretical Astrophysics. The theoretical astrophysics group, which recently underwent a major expansion, has continued its vigorous development. Various members of the group are pursuing research interests ranging from the nature and origin of solar-system bodies, through the evolutions of stars and stellar systems, to problems in galaxy clustering, gravitational lensing, and cosmology.

The first two postdoctoral fellows of the group are now moving on: Dr. Steven Balbus will take a second postdoctoral position at Princeton, and Dr. Stephen Kent will become an assistant professor at Harvard.

II. Cosmology and Gravitation. We have continued our program to measure the large angular scale intensity distribution of the 3K cosmic background radiation at millimeter and submillimeter wavelengths from balloon-borne platforms. We have established that the dipole anisotropy measured in the 3 to $10cm^{-1}$ band has an amplitude of 2.96 mK, approximately 1/1000 of the background intensity. The direction and amplitude are in agreement with lower frequency measurements establishing that the spectrum of this anisotropy is appropriate to a thermal source. The search for higher order angular anisotropies is limited by foreground emission by interstellar dust.

Ground based measurements of the Compton shift of the 3° K background by hot electrons in intra-cluster plasmas have been made at the Infrared Telescope Facility in Hawaii using a multi-band radiometer. The instrument covers 2 to $8cm^{-1}$ in four bands. We have set an upper limit of 0.8 m°K for the shift in Abell cluster 1795. The technique successfully uses the correlation of the four channels to remove atmospheric fluctuations to the detector noise limit.

Work continues on the development of a prototype interferometric gravitational wave antenna and the study of the design and costs of a large antenna system to achieve sensitivities of 10^{-23} $Hz^{-1/2}$. The image antenna project is envisaged as a Caltech-MIT collaboration having antennas near both coasts.

III. Microwave Spectroscopy of the Interstellar Medium. During 1982 the following programs of research on the interstellar medium were pursued. A. A detailed study of the Sgr A molecular cloud, located approximately five arc-minutes from the galactic center and believed to be closely associated with the center, has been completed in the microwave lines of NH_3, HNCO, and $C^{18}O$. The ℓ-b and ℓ-v maps in NH_3 and HNCO are very similar, suggesting that both molecules are probes of high-density (10^4 cm^{-3}, and greater) material. The $C^{18}O$ ratio varies by a factor of 10 in the cloud. This variation is believed to be attributed to differences in chemical composition within the cloud. VLA observations of the NH_3 J, K = 3,3 line reveal condensations within the Sgr A cloud wnose angular size is less than five arc-seconds, corresponding to a linear dimension of 0.25 pc, with brightness temperatures of the order of 100 K. Only about 15 percent, or less, of the NH_3 appears to be in identifiable condensations. B. The NH_3 lines have been regarded as a fairly reliable "thermometer" of the interstellar gas because the intensities of the hyperfine lines could be fit very closely with a single excitation temperature. However, examples have now been found where this is not the case. We have found at least five sources which exhibit hyperfine intensity anomalies. We hope to be able to correlate this effect with other properties of the source, such as an IR source, nigh-velocity outflow, OH and/or H_2O masers, etc. C. The molecular clouds in the Taurus region have been studied in the CO line at 2.6 mm. A large amount of data was acquired, using the 1.2 m telescope of Columbia University and the Goddard Institute of Space Studies, and is not fully reduced. However, one significant conclusion is the detection of a large shell of CO surrounding a group of T-Tauri stars. This shell may have originated from the mass loss of the T-Tauri stars. D. A deep, continuum study of tne Sgr A molecular cloud with the VLA at 6 cm and 2 cm has revealed the presence of both thermal and nonthermal sources in the cloud. These sources were previously undetected but their relationship to the cloud is quite clear since they have a positional coincidence with the NH_3 peaks in the cloud. Further studies are planned.

Atomic, Condensed Matter, and Plasma Physics

I. Atomic, Molecular, and Laser Physics. New results have been obtained in studying atoms in highly excited quantum states, called Rydberg atoms: atoms have been produced in a state of maximum angular momentum corresponding to nearly circular motion of the electron. These states are the only ones non-degenerate in applied fields and open the responsibility for study of suppressed spontaneous emission, higher precision measurement of the interaction of the atom with fields and of the Rydberg constant. Experiments to demonstrate quantum diffraction during collisions involving radiating atoms have been carried out with ytterbium atoms; the use of optical excitation to polarize atomic nuclei, begun last year, has been applied to measure the isomer shift in the short-lived nuclide ^{134m}Ba(10+). A theoretical controversy over the interaction of atoms with intense radiation fields has been resolved by an MIT experiment that demonstrated diffraction of sodium atoms by a standing wave laser field.

Experimental work on molecular collisions in which there is a change in vibrational energy of the molecules has been extended to cases where there is also a rotational energy change; the rate constants have been found to vary dramatically with initial and final rotational energy of the molecules. This result is unexpected and has not been previously observed. Resonant vibrational energy exchange processes have been studied in CH_3F; these are potentially useful to transfer energy from laser excited molecules to the entire excited rotational manifold of a population of molecules.

In the area of laser physics, the theory of a single mode periodic heterostructure laser has been developed. Preliminary results have been obtained on a free electron laser apparatus, and experimental and theoretical work on single quantum well luminescence for laser action in high magnetic fields is under way. Following an extensive theoretical study, experimental work on integrated optical devices which combine quantum electronics with electron tunneling spectroscopy has begun.

II. Biological Physics. With a grant from the IBM Corporation, apparatus has been developed which permits light scattering observation of the Brownian motion of molecules within a single living cell. Applied to red blood cells, it has provided the first *in vivo* confirmation of the mechanism for sickle-cell anemia. The same apparatus has also been used to study the synthesis of the lens-specific protein crystallin as it occurs during the development of the chick embryo. Study of other intracellular processes, such as the transformation of normal to malignant cells, is envisioned.

The development of a scanning desorption molecule microscope with micron spatial resolution was completed in 1982. The apparatus uses focussed pulses of laser light to desorb molecules which are detected by a mass spectrometer. With anticipated improvements in efficiency, nanometer resolution should be possible.

Progress has continued using time dependent percolation theory and recent theoretical work on chaotic states to understand ventricular fibrillation in the heart; experimental studies have verified many of the ideas. The statistical analysis of random fluctuations of respiration and heart beat is being used to develop non-invasive diagnostic techniques for cardio-respiratory diseases.

Light scattering studies of transformations in the structure and density of high density lipoprotein model systems has elucidated the precise mechanisms for transportation and degradation of cholesterol *in vivo*. These findings are of fundamental importance in understanding the molecular basis for atherogenesis, and the student involved in the research was awarded the Student Research Prize of the American Gastroenterological Society.

III. Condensed Matter Physics. The condensed matter theory group has moved to new office space which alleviates many of the problems caused by crowding in their previous quarters. Recent work has involved the development of the first chaotic renormalization group, enabling this powerful computational tool to be applied to random systems such as spin glasses. Activity has continued on explaining the properties of gases absorbed on the surface of crystalline solids, with particular emphasis on the recently discovered behavior of a solid phase that melts as the temperature is lowered. Work also continues on the metal-insulator transition in disordered electron gases and numerical solution of a theory of the fractionally quantized Hall effect revealed the interesting result that the ground state of the electrons in this system is a liquid. Numerical calculations of the total energy in a microscopic model for chemisorption on crystalline solids and inter-defect correlation energies in amorphous semiconductors have been successfully carried out.

Experimental studies by X-ray scattering using synchrotron radiation have been carried out on several systems with competing interactions. These include commensurate-incommensurate transitions in surface adsorbed gases, behavior of systems with random fields, and the phenomenon of wetting. Interesting results have been obtained for the wetting of graphite by ethylene, and a surface adsorbed solid which melts when cooled has been observed.

Experimental studies of liquid crystal materials have been extended to ordered phases of soaps, and preliminary results indicate that the statistical mechanics of surface active molecules can be elucidated by the same experimental and theoretical tools as conventional liquid crystal materials.

There has been considerable progress on investigations of the quantum fluid formed by spin polarized atomic hydrogen. A new technique, based on mechanical compression, enabled the production of record densities of spin polarized gas. Studies of three-body recombination and its role in destabilizing the gas are in progress.

Experiments to use submicron fabrication techniques to produce devices in which a quasi-one-dimensional electron gas can be studied have been successful. Preliminary measurements showed changes from metallic to insulating behavior and back again as electrons were added to the gas. Work to understand the properties of amorphous semiconductors continues; recent photoluminescence studies have identified the nature of electronic states in As_2Se_3.

Experiments in the neutron diffraction laboratory have demonstrated that slow neutrons passing through a crystal lattice are characterized by an effective mass far smaller than the normal mass (by 5 or 6 orders of magnitude) which can be positive or negative in sign. This is a quantum effect analogous to the behavior of electrons in semiconductors.

Interesting new results have been obtained in infrared nonlinear optics. Highly efficient degenerate four wave mixing has been observed with CO_2 excitation in (Hg,Cd)Te. Predicted theoretically many years ago, acoustic plasma waves have been observed for the first time in studies of optically excited electron-hole plasmas in GaAs.

IV. Plasma Physics. The stability of magnetically confined plasmas is a problem of high current interest. Theoretical work at MIT dating from 1978 has been applied to explain the formation of energetic ion populations in the upper atmosphere of the Earth's auroral region and resolve a long-standing debate. These ideas are now being used to guide the design of laboratory magnetic confinement experiments.

The lower-hybrid resonance heating project for the Alcator-C tokomak has been very successful. Plasmas at reactor level densities (1.5×10^{14} cm^{-3}) have been heated to temperatures as high as three kev. Basic research has also continued on the Versator II machine.

As a result of extensive experimental work, computer simulation, and theoretical studies, free electron laser research has reached a high level of maturity. MIT efforts have concentrated on lasers operating in the high current regime; particular success has been achieved in the construction of a circular free electron laser in which electrons orbit in a azimuthally periodic magnetic field.

Experimental Nuclear and Particle Physics

I. Heavy-Ion Reactions. Research in heavy-ion reactions is concerned with a study of nuclear structure, such as the population of exotic nuclear states (e.g., high spin, large deformation), and the dynamics of collisions of complex nuclei. Our experimental program is centered at Brookhaven National Laboratory (BNL), but with extensive use being made of other laboratories. A new Recoil Mass Selector (RMS), built at MIT, and based on experience gained from design and construction of the MIT-BNL RMS, is now in operation at Oak Ridge National Laboratory (ORNL). We plan to make full use of this new instrument.

One of the newest and most exciting topics in heavy-ion physics is the discovery of dramatic isotopic differences in sub-barrier fusion cross sections. These measurements were pioneered at MIT, and were made possible by the MIT-BNL-RMS. Analysis of sub-barrier fusion yields may reveal information about the structure of the colliding nuclei as well as any dynamical effects in the reaction. Measurements of elastic, inelastic or transfer reactions are being made to complement the fusion measurements and test a number of nuclear reaction models. The systematic study of sub-barrier fusion is yielding important insight into the dynamics of the fusion of massive nuclei. This is relevant to the search for super-heavy elements (i.e., Z>107), which we are pursuing with the help of the MIT-BNL and ORNL Recoil Mass Selectors. The search for element 109 is being made at BNL, and we plan to extend our search at ORNL.

It is possible, with the use of a Recoil Mass Separator, to systematically study the limitations to fusion in heavy-ion reactions, even in regions of the periodic chart where energy level schemes are not known. The limiting angular momentum for the formation of a compound system which does not subsequently fission, is obtained from measurements of γ-ray multiplicities. The systematics of the limiting angular momentum can be used to test nuclear models (e.g., liquid-drop models). It may also be possible to extract structural information from the excitation function of the mean γ-ray multiplicity.

The interest in heavy-ion resonances has increased with the recent discovery of resonances in systems as heavy as $^{28}Si + ^{28}Si$. Our study of resonances in the $^{12}C + ^{12}C$ system indicates that these resonances are extremely deformed ^{24}Mg states. An explanation of heavy-ion resonances in terms of the nuclear shell model would be very appealing, allowing for a study of nuclear states of very large spin and deformation. We are presently attempting to obtain an effective ion-ion potential for systems which exhibit resonances and are continuing the search for resonances in systems heavier than Si + Si.

II. Medium Energy Nuclear Physics. Research in this broad area at the boundary between nuclear and particle physics is concentrated at the MIT Bates Linear Accelerator, where electron and photon beams of energy up to 750 MeV are available. Complementary experiments with proton and pion beams at the Indiana University Cyclotron Facility and the Los Alamos Meson Physics Facility are also being performed.

This past year has seen the completion of a number of major new facilities at Bates. First, the maximum beam energy has been increased from 400 MeV to 750 MeV by means of recirculation of the beam a second time through the linear accelerator. Second, two new magnetic spectrometers have been brought into operation on one of the beam lines in the South Hall.

This new equipment is now in use and is beginning to yield very interesting new data. Some notable recent examples include (1) For the first time a measurement has been made of the tensor polarization of the recoil deuterons in elastic electron scattering. This allows the separation of the charge monopole and quadrupole form factors. These measurements were performed in the South Hall using one of the new spectrometers by a collaboration including scientists from MIT, WPI, ANL, Illinois, LANL and TRIUMF. (2) Data taking has commenced in studies of both the $(\gamma\pi)$ reaction and the (γp) reaction. (3) Successful feasibility tests have been conducted into the possibility of conducting momentum measurements using the two new spectrometers for (ee'p) studies. (4) Using beam energies up to 750 MeV, a program of measurements in deep inelastic electron scattering, including Δ excitation, has been started.

In addition to the work at Bates the group is engaged in complementary experiments at Indiana University Cyclotron Facility and Los Alamos Meson Physics Facility. Among experiments recently completed are (1) the spin flip excitation of states in ^{12}C by means of the $(p,p'\gamma)$ reaction in which the gamma rays were detected normal to the scattering plane, (2) measurements of the $^{2}H(\pi^-,\pi^+\pi^-)$ reaction, (3) studies of the $(\pi,2p)$ reaction and (4) high resolution scattering of 400 and 800 MeV protons from a number of nuclei.

III. Experimental Particle Physics. A. Counter Spark Chamber (CSC) Group. The CSC Group has continued its Fermilab-based program of studying the structure of the nucleon and the structure of the weak interaction using neutrinos as a probe. The major focus now is on the analysis of the data obtained last year to determine the structure functions of the nucleon, as sensed by the weak neutral current, and to make detailed comparisons of the neutral and charged current interactions with the nucleon. These results will allow detailed comparison with the expectations based on other data and the predictions of weak-electromagnetic unified theories (e.g., the Weinberg-Salam theory).

We are eagerly awaiting the increase in energy to one TeV at Fermilab (the "Tevatron II") at which time we will extend our neutrino studies to the new energy domain.

In addition the group has more recently entered into two other major collaborative programs. (1) The use of μ mesons at the Tevatron to study nucleon structure and the mechanisms of particle production. The group is participating in the construction of a spectrometer to be used in these studies. (2) The use of 50 GeV e^+e^- colliding linac beams (SLC) at the Stanford Linear Accelerator Center to investigate the physics of the intermediate vector boson Z^0. The collaboration has proposed an advanced detector, called SLD, which would exploit the new energy region to investigate a number of physics issues. In particular, we will search for Higgs particles, produced in the decay of the Z^0. In addition, we will search for processes involving heavy quarks with hitherto undiscovered flavors. B. The Accelerator Physics Collaboration (APC) Group. The APC Group is conducting experimental research on the nature and interactions of photons, hadrons, and neutrinos. The experiments are performed at two of the country's national accelerator laboratories: the Stanford Linear Accelerator in California and the Fermilab Accelerator in Illinois. In the Stanford experiment the goal is to see how photons, which are massless vector quanta of the electromagnetic force, change into vector mesons, which are massive quanta of the nuclear force. Since one of the vector mesons which the photon can change into is the D meson containing a charmed quark, these charmed mesons are being studied intensively.

An experiment at Fermilab, completed one year ago, was designed to study how hadrons made up of one set of quarks generate hadrons with other types of quarks or other combinations of the same types of quarks. For this study a unique device was developed that identifies each particle produced. The device, called CRISIS, worked well and should give information never previously available. The data from this experiment are currently being analyzed.

A future experiment has been approved for running at Fermilab in 1985, apparatus for which is being designed and built now. The goal of the experiment is to search for a hitherto undiscovered particle, the τ neutrino. Proof or denial of its existence will have major theoretical consequences. This experiment will use a new technique being developed explicitly for it--holographic photography of a bubble chamber. The technique will provide a factor of 10 improvement in resolution.

All of these experiments are being done in collaboration with a consortium of universities in Japan, China, Israel, Italy, France, and the United States. The APC Group, which has been the organizer of the Fermilab experiments and the consortium performing these experiments, has four faculty members, three postdoctoral physicists, nine graduate students, 11 undergraduate students, as well as programmers, engineers, film scanners, technicians, data analysts, and secretaries. C. The Electromagnetic Interactions (EMI) Group is beginning construction of a large new experiment for the Large Electron Positron collider (LEP) now being built in Geneva, Switzerland. This machine will provide uniquely large e^+e^- energies, increasing from E_{cm} of about 45 GeV now available at PETRA up to E_{cm} of 260 GeV. In this energy range the full complexity of the electroweak interaction should reveal itself perhaps with unanticipated additional surprises. A large international collaboration led by MIT will construct one of the three experiments to be ready at the start-up of the new machine. This experiment emphasizes high resolution studies of electrons, muons, photons, and hadron jets. The cost of construction of the detector will be around $50 million. MIT will play a dominant role in the construction and analysis of the experiment.

We have also collected a large amount of data on electron positron annihilations at PETRA during this year. An increase in the accelerator beam energy allowed us to place new limits on the mass of the expected sixth "flavor" of strongly interacting particle, the top quark, as well as on other hypothetical new particles. We have also gained important new information about the strong and electroweak interactions. The strong interaction's dimensionless coupling constant, α_s, whose value has similar significance to particle physicists as does the charge on the electron, has been determined to a better precision by comparing our data to a higher order QCD calculation. Limits on the mass of the weakly interacting neutral boson, the Z^0, have been improved to the point that we finally rule out the four fermion theory of weak interactions proposed in the 30's in favor of more modern theory like the Glashow-Weinberg-Salam model. This has been achieved by making a high precision measurement of the forward-backward charge asymmetry in $e^+e^- \rightarrow \mu^+\mu^-$. Finally we have gained new information about the way the quarks which one produced in e^+e^- collisions turn themselves into the hadrons which we then observe. This process, known as fragmentation, seems to depend strongly on the mass of the quark which is fragmenting. In particular, we find that the heavier a quark is the more momentum is carried away by the final particle which carries its flavor quantum numbers. The PETRA machine energy will continue to increase in small steps during the next year.

Nuclear Theory

I. Hadronic Forces and Quark Degrees of Freedom. A. The dynamical effects of confinement and color on a composite system have been considered in a non-relativistic model. Bound states and resonances on a background of hard core-like phase shifts result even in the absence of internal degrees of freedom. B. It has been shown that consistent current quark bag models predict dibaryon structures with well defined inelasticity. The $^1S_0$ and ^3S, dibaryons are expected to be below three GeV and separated by an energy of about 100 MeV. C. The effect of intermediate isobar states on nucleon-nucleon scattering at low and intermediate energies have been considered leading to the conclusion that $\Delta\Delta$ and nucleon-Roper admixture is about 2.5 percent.

II. Quark Degrees of Freedom in Nuclei. The consequences of quark-gluon degrees of freedom on heavy ion collisions and the properties of nuclear matter are under consideration.

III. Electromagnetic and Weak Interactions in Nuclei. An analysis of all aspects of electromagnetic interactions with nuclei is of great importance to analyzing results of experiments at the Bates Linear Accelerator and in determining the experiments of importance for future intermediate energy electron facilities. Of current interest are the studies of elastic magnetic electron scattering, electroexcitation of discrete states in ^{40}Ca, quasi-elastic electron scattering sum rules, ^4He photo-disintegration and electron capture from the continuum. A new approach to calculation of meson exchange of current contributions in heavy nuclei is being applied to a variety of nuclear states involving particle-hole excitations. A complete study of scattering polarized electron beams (soon to be available) on polarized nuclear targets is being made.

Higher energy electron beams are expected to be available in a few years. Predictions are being made of (γ,K) and $(e,e'K)$ reactions with improved production operators and kaon wave functions in the nucleus. Also predicted are the properties of resulting hypernuclear states.

The effects of weak neutral currents on nuclear transitions can lead to important information on their space-time and internal symmetries as well as to their interaction strengths. The sensitivity of elastic neutrino scattering has been studied for nuclei from ^2H to ^{56}Fe. Neutrino reactions in the deuteron have been studied as well.

IV. Many-Body Theory and Nuclear Collective Motion. For many years the nuclear theory group has done intensive and broad research on many-body theory, and this past year was no exception. There has been work on new many-body formulations and techniques with applications to ground state properties, collective excitations, optical potentials, reactions, and fission. New methods involving functional integrals, Monte-Carlo and spatial lattice techniques have played an increasingly important role.

A. Monte-Carlo methods have been used to solve a one-dimensional fermion model exactly. This is enabling exploratory investigations of the validity of various important approximations. B. In a similar model the effect of virtual excitation of anti-nucleons from the Dirac sea is being investigated. C. A model field theory of nucleons coupled by vector and scalar fields in one dimension has also been investigated by stochastic techniques using trial field functionals. Calculations for systems of up to 20 particles show that the static limit is adequate but that the mean field approximation is not. D. The functional integral method with complete sets of pairing wave functions has identified a new pairing vibration contribution to the zero-point ground state energy. E. The derivation of an energy independent optical potential with a microscopic multiple scattering formalism has shown that such potentials have pathologies which negate their usefulness. F. The absorptive part of a relativistic optical model has been calculated for the first time and agrees with the phenomenology. G. A new Feynman-Goldstone time dependent purturbation theory has been derived and applied to collective levels. Quantization is also being studied through a technique of finding solutions to periodic, self-consistent time dependent Hartree-Fock equations. H. A Born-Oppenheimer expansion of many-body Hamiltonian in powers of the conjugate momentum to a collective operator has been developed as a practical way of calculating quantum corrections to semi-classical collective effects. It is being used to study rotation-vibration spectra and recoil effects in inelastic scattering to collective states. I. In another formalism a time dependent variational principle has been developed to study dissipation in collective motion and the wobbling of high angular momentum rotational states. J. Fission has been studied by Monte-Carlo techniques with the one-dimensional fermion model and predicted fission lifetimes are being compared with the standard one-dimensional barrier penetration model. Using a Cray computer the work is now being extended to three

dimensions for A $\lesssim$ 50. K. It has been found that heavy ion subcoulomb fusion cannot be described by one-dimensional tunneling. L. A self-consistent RPA formalism has several important applications. It shows that some collective states have vortices ruling out irrotational fluid models of giant resonances. Through application to the giant monopole resonance the compressibility of finite nuclei can be extracted. The effect of possible surface compressibility on extrapolation to infinite matter is found to be significant and can affect the results of supernovae calculations. The RPA method has also been used to study the A-dependence of the spreading width for different multipolarity resonances. M. The potential surfaces for the interacting boson model were calculated and its extrema were investigated. Angular momentum projection techniques were used to calculate total partition functions for fixed J for spherical nuclei. Calculations for deformed nuclei are in progress. New analytical solutions of a supersymmetric Interacting Boson-Fermion model accurately predict energy levels and electromagnetic transition rates of ^{195}Pt.

V. Nuclear Reactions and Medium Energy Hadron Physics. A. In the study of statistical multi-step direct reactions the important issue of how the effect of the direction in time is taken into account in a stationary state theory has been resolved. The method successfully describes nucleon induced reactions including recent polarization experiments. The flow of matter, momentum and energy in low-energy, heavy-ion collisions has been studied with the Wigner phase space distribution function, demonstrating significant energy flows perpendicular to the beam. The matter current for mass-asymmetric systems is now being studied. A. Many important studies of the effect of pions and Δ-isobars in nuclei have been made using the Δ-hole formalism developed here. A pion optical model consistent with data was constructed including the exclusive (p,π^0) reactions as well as analyses of Compton scattering and total photo-absorption. The need for strong damping of Δ propogation in the nucleus is demonstrated, altering the structure of inelastic pion scattering to particle-hole states and decreasing the isospin mixing parameters. C. A Λ-hole formalism has been used to investigate strangeness analog collectivity. The presence or absence of such collectivity is found to be very sensitive to the space exchange part of the Λ-N force. The predictions for the (K^-,π^-) reaction are being calculated. D. The influence of an intrinsic quadrupole moment of the Δ on pion-proton bremsstrahlung is being calculated in a dramatically consistent isobar model.

Particle Theory

Research in the past year has continued the main themes of recent years, particularly the structure and applications of gauge field theory. A broad division is (1) investigations of structure of field theories, including studies of non-perturbative effects in model systems; (2) detailed studies of quantum chromodynamics as the theory of strong interactions and hadron structure; (3) cosmological applications of grand unified theories. Some of the developments are described more fully below.

I. Structure of Field Theories. A. A new phenomenon in field theories was discovered as a consequence of our recent work on some three-dimensional model theories. Certain parameters must have integer values for these theories to be consistent. Important applications of phenomena of this type have been suggested by other physicists and are being intensively studied. B. A detailed investigation of the Liouville theory has found an example of spontaneous dynamical compactification of space, a phenomenon of great interest as a possible way in which unification of all forces with gravity may occur. C. Studies of solitons with fractional quantum numbers continued. A class of examples in relativistic field theories analogous to some of the more complex known polymer cases has been constructed. D. The stability of the vacuum against small fluctuations in unified extended supergravity theories was demonstrated. It now appears that these theories are consistent quantum field theories, an important result since they are leading candidates for the real unified theory.

II. Quantum Chromodynamics (QCD). A. Efficient methods to compute heavy quark bound states in lattice gauge theory which emphasize the configurations dominant in simple physical pictures of the system are being developed. Preliminary results of computation are encouraging. B. The powerful methods developed earlier to calculate gauge field theory effects inside a confining cavity are being used to make realistic computations of self-energy effects. C. Formal low energy theorems derived from QCD have been turned into a practical method to investigate the structure of the QCD vacuum wave-function using information from the pseudo-scaler flavor singlet mass spectrum. D. Recent experimental results on deep inelastic scattering of muons on iron and deuterium indicate a modified quark distribution inside nuclear matter. This effect has been analyzed in terms of the parton model and an explanation based on QCD ideas has been suggested.

III. Cosmological Theory. The "new inflationary universe" scenario, a modification of the original model suggested by Guth continues to be the subject of intense interest. Here a calculation of particle production has shown that today's observed baryon density can be explained by the model with a reasonable choice of parameters. However, the crucial question, the subject of much controversy, is whether the scenario can generate the spectrum of fluctuations needed to explain the evolution of galaxies. At present all versions seem to give too large fluctuations, and work continues on the calculation of the fluctuations and the research for a model which avoids the difficulty.

HERMAN FESHBACH

Experimental Study Group

This past year ESG enrolled 52 freshmen, 31 sophomores, and two transfer students for one or more terms, one of the highest enrollments in ESG's history. On the average the freshmen completed 51 units each term, taking approximately three subjects in ESG and two subjects in the regular curriculum. The percentages of women, minority, and international students registered in ESG (21 percent, 9.6 percent, and 15.4 percent respectively) were the same or higher than the corresponding percentages for the MIT freshman class for the third consecutive year. Last year's freshmen in ESG achieved a median grade point of 4.28 during their sophomore year, compared to the 4.0 median grade point for all MIT sophomores. Two thirds of the students who were in ESG last year as freshmen continued to take one or two subjects in ESG, mostly in math and science.

ADMINISTRATION

Professor Robert Halfman (Director) and Holly Sweet (Associate Director) oversaw the administration of the program in conjunction with the ESG Advisory Committee. Professor Alan Davison, in his third year as a committee member, assumed the chairmanship from Professor Robert Alberty. Professor Arthur Mattuck also finished his third year on the Committee. New members included Professor Arthur Kaledin from the Department of Humanities, Dr. Alan Lazarus from the Department of Physics, and Associate Provost Frank Perkins. ESG welcomed continued fiscal support from the School of Science under the new leadership of Dean John Deutch.

STAFFING

A variety of subjects in mathematics, physics, chemistry, and humanities and social science were offered through a combination of tutorials, seminars, and supervised independent study projects. The mathematics staff consisted of Dr. Lawrence Ein and three graduate students: Deborah Franzblau, Mark Haiman, and Dominique Haughton. The physics staff was composed of Professor Emeritus Nathaniel Frank and Professor Halfman, and two graduate students: Peter Dourmashkin and Eduardo (Jay) Olaguer. Miguel Mitchell, a recent graduate of the Department of Chemistry at MIT, served as a teaching assistant for students taking 5.41 Introduction to Structure, Bonding, and Mechanism, and 5.42 Organic Chemistry. The humanities staff, headed by Dr. Janet Murray, included Professor Stephan Chorover and Ms. Sweet, as well as two graduate students (Susan Rothstein and Charles William Ryan) and two senior undergraduate tutors (David Custer and Deborah Pekala). Seven humanities subjects were offered, over half of which received distribution credit: 21.004 Major Poets, 9.00 Introduction to Psychology, Ethics, Philosophy of Science, Technology and Society, Three Approaches to Psychology, and Writing Workshop. The ESG staff was assisted by 26 undergraduate tutors who worked closely with staff members in instructing students in the program.

CURRENT DEVELOPMENTS

ESG has continued to serve as one measure of MIT's strong commitment to undergraduate education by providing faculty and students with the opportunity to participate in an academic community which stresses close staff-student interaction and individual initiative. ESG's extensive use of supervised undergraduate tutors has enabled the program to provide high quality personal instruction at a relatively low cost. Professor Emeritus Frank initiated a bi-weekly teaching seminar for physics tutors which was well received and will serve as a model for similar seminars in other subjects. ESG participated in the Undergraduate Seminar program for the second time by offering SEM051 Sex Roles and Androgyny, taught by Ms. Sweet and supervised by Dr. Murray. Plans are being made to offer several seminars (some of them student-initiated) for the coming year. Dr. Murray is heading an investigation into ways of utilizing computer-assisted instruction within the program. We are pleased to support these efforts and will be working with our Advisory Committee to enable other programs and departments within MIT to take advantage of such developments in the future.

ROBERT L. HALFMAN
HOLLY B. SWEET

Center for Cancer Research

During the academic year 1982-83 several honors have been conferred upon members of the Center for Cancer Research (CCR) faculty. Professor Phillip A. Sharp was elected to membership in the National Academy of Sciences, bringing to four the total number of members among the CCR faculty. Professor Susumu Tonegawa shared the Louisa Gross Horwitz Prize of Columbia University. Professor Robert A. Weinberg was selected as Scientist of the Year by Discover magazine for his outstanding research on oncogenes from human and animal cancers, and was designated as co-awardee for the Warren Triennial Prize of the Massachusetts General Hospital; this prize will be awarded in the fall 1983. Professor Richard C. Mulligan was awarded a Searle Scholarship of the Chicago Community Trust.

Research has continued to be supported by grants from public and private agencies. We are especially grateful for special awards from the Bristol-Myers Foundation, the Culpepper Foundation, Abbott Laboratories, and the Cancer Research Institute, Inc.

Dr. David H. Raulet, Ph.D. MIT 1981, was appointed Assistant Professor of Immunology, to replace Professor Michael Bevan. Professor Raulet's program on soluble factors through which classes of lymphocytes communicate and become programmed is an important new approach in our Center, directed ultimately to identify the mechanisms of cancer cell elimination in the body.

Professor Richard O. Hynes spent the academic year on sabbatical leave at University College in London. Professor Salvador E. Luria spent most of the spring term 1983 as a Fellow of the Center for Advanced Studies in the Behavioral Sciences in Palo Alto, completing an autobiography to be published by Harper and Row.

Visitors of faculty rank in the Center during the year include Herbert Abelson, M.D., Associate Professor of Pediatrics, Dana-Farber Cancer Institute, and Mark Pasternack, M.D., Instructor in Pediatrics, Harvard Medical School and Assistant in Pediatrics and Clinical Assistant in Medicine at Massachusetts General Hospital.

SALVADOR EDWARD LURIA

Center for Space Research

The MIT Center for Space Research (CSR) conducts an active program of research in space science and technology, with emphasis on experimental and theoretical investigations in support of various NASA missions; although the primary source of support is from NASA, a substantial fraction of the research program is sponsored by NSF and by DOD. Specific areas of research include X-ray astronomy, interplanetary plasma, space plasma physics, the life sciences, properties of planetary surfaces and atmospheres, and radio astronomy. A major part of this program concerns the analysis and interpretation of data from flight experiments carried out in these areas. The current long-range NASA flight program includes several missions in which MIT and the Center are heavily involved. Among these are the Venus Radar Mapper (VRM), the Advanced X-ray Astronomy Facility (AXAF), a Large X-ray Timing Experiment (XTE), and a large-scale investigation of the plasma environment of the earth (OPEN). During the past year, the Center has been increasingly involved in a program designed to investigate the plasma environment experienced by the Space Shuttle in a typical polar orbit. The Center also supports a program in theoretical astrophysics and optical investigations carried out at the McGraw-Hill Observatory as described elsewhere in this report. An overview of CSR activities during the past year follows.

RESEARCH AND ANALYSIS PROGRAMS

X-RAY AND γ-RAY ASTRONOMY

Analysis of Data from Past X-ray Astronomy Missions

During the period from 1975 to 1981 various instruments developed by members of the X-ray Astronomy Group were flown on three NASA satellites, SAS-3, HEAO-1, and HEAO-2. The archives of data from these missions continue to be valuable sources of material for research on the properties of galactic and extragalactic X-ray sources which is carried out in the X-ray astronomy computation facility at CSR. The MIT X-ray Observatory on SAS-3, operated under the direction of Professor George W. Clark, was used extensively from 1975 to 1979 by various members of the group in observations of X-ray emitting binary star systems and other objects. During the past year, Professor Walter H.G. Lewin and his students have investigated the properties of X-ray bursters, and Professor Saul A. Rappaport has studied the dynamical properties of X-ray pulsars with Dr. Richard Kelley. Two experiments on the HEAO-1 satellite, operated from August 1977 to January 1980 under the direction of Professors Lewin and Hale V. Bradt, respectively, provided the data for studies of the location and spectra of X-ray sources carried out during the past year by Dr. Alan M. Levine and Ronald Remillard. The HEAO-2 satellite, otherwise known as the Einstein Observatory, carried a Bragg-reflection X-ray spectrometer developed by Professors Clark and Claude R. Canizares. Among the results reported this year is the first observation by Dr. Thomas Markert and associates of a Doppler shift in an X-ray emission line from a galactic source, the supernova remnant Cas A.

Balloon-Borne and Ground-Based Gamma Ray Experiments: The Explosive Transient Camera (ETC)

During the past year, there has been a major change in the experimental program of balloon-borne X-ray experiments directed by Dr. George R. Ricker. This change in emphasis has resulted from the discovery (by an MIT graduate student) that gamma ray bursts are apparently associated with a brief enhancement of optical emission from the celestial source. This observation coupled with the availability of powerful new observational techniques has resulted in a program to develop an "all-sky camera" capable of observing the brief flashes of optical emission. Initially, it is proposed to operate this device from the ground and correlate the results with gamma ray observations by satellite-borne detectors. Later on a balloon or satellite-borne experiment which incorporates both the ETC optical array and appropriate gamma ray detectors is planned.

A compact "fly's eye" array of 16 microprocessor-controlled electronic cameras, each viewing adjacent 28° x 28° patches of sky, is currently under development. Using ultrasensitive charge-coupled devices (CCDs) with 70-80 percent peak efficiencies developed at MIT and simple 35mm-type lenses, all objects as faint as 10th magnitude can be examined once per second over ~60 percent of an accessible hemisphere. Any "new objects" detected will be electronically flagged, and information describing their location and intensity will be stored in an on-site memory and transmitted (through a modem link) to MIT. Initially, the Explosive Transient Camera (ETC) arrays will be housed in a small (~ 4' x 4' x 4') building on Kitt Peak in Arizona. The transparent roof over the array will be opened and closed by an overseer

microcomputer, based on its assessment of sky clarity and cloud cover measurements made through the roof. Human intervention should be necessary only for preventative maintenance.

A single array element prototype was successfully tested in April 1982 by an MIT team at Mauna Kea Observatory (Hawaii). Observed values for sky brightness, detector sensitivity and noise level closely matched previously calculated values. Since no other technical limitations are foreseen, design and construction of a "full up" array was begun as soon as funding became available in early 1983.

The ETC will be able to detect brief (~ 1-10^2 sec duration) flashes of optical light with an efficiency about three orders of magnitude better than previously used astronomical methods. Based on the discovery of Schaefer here at MIT in 1981 of the first optical burst associated with the gamma ray burst (GRB) sources, we can expect to detect and precisely locate $\sim$100 such events per year with the ETC. To detect a comparable number with traditional methods (for example, using the Mount Palomar Schmidt telescope) would require $\sim$500 years of observing.

Optical and Infrared Studies of X-ray and γ-ray Sources

Two major systems were added to the scanning slit photometer used by Dr. Jeffrey E. McClintock and Ronald Remillard to study the optical counterparts of X-ray binaries: a microprocessor system for instrument control and data acquisition, and a CCD television system for viewing faint stars on the aperture plate. The photometer is now a fully "stand-alone" instrument. It was used to search for orbital periods in X-ray burst sources at the Cerro Tololo Interamerican Observatory in Chile in April and the South African Astronomical Observatory in June.

During 1982-1983, Dr. Ricker and his collaborators carried out an extensive search for near IR (~2μm) counterparts for a class of optically empty-field, high galactic latitude X-ray sources, using the NASA Infrared Telescope Facility (IRTF) (Mauna Kea, Hawaii). This search was successful in detecting 16 out of 25 objects searched for. The extreme infrared excess of these extragalactic sources has been taken as evidence for their possibly being either primeval galaxies or very high redshift quasars. Very deep optical searches with the MASCOT CCD instrument on 2- and 4-meter class telescopes should permit a more definite assessment of the origin of these rather mysterious objects.

In another program with the IRTF, counterparts for the gamma ray burst sources GRB 0116-289 and GRB 2251-02 were carried out. The upper limits from these sensitive searches delineated possible models for the quiescent sources (Schaefer and Ricker, published in Nature).

Rocket-Borne X-ray Experiments

During the past several years, the MIT X-ray Astronomy Sounding Rocket group, under the direction of Professor Rappaport, has designed and constructed a new wide-field soft X-ray camera. The instrument features three nested Wolter-Schwarzschild grazing incidence mirrors, and a 50mm diameter microchannel plate imaging detector at the focal plane. The camera has an 8° field of view and is sensitive over the energy range 50Å-250Å. We plan to use this instrument to carry out an all-sky survey in this relatively unexplored wavelength band. It is expected that important new astrophysical information will be obtained for a wide range of astronomical objects. The payload was launched from White Sands last October and is scheduled for a second flight early this fall. A satellite experiment, with its longer exposure times, could enable a truly high-sensitivity all-sky survey to be carried out using this technique. Accordingly, a scaled-up version of this instrument has been successfully proposed by a consortium of British astronomers as an ancillary experiment on the German satellite ROSAT.

SPACE PLASMA PHYSICS

Interplanetary and Magnetospheric Plasmas

The IMP-8 spacecraft was launched in 1973 into an eccentric earth orbit. It has provided a continuous database of solar wind plasma conditions at 1 Astronomical Unit (AU) for the past nine years. At the present time, there are no other operational solar wind experiments in earth orbit. Thus, the IMP-8 results constitute the only available database. The data are processed routinely, and are used by many investigators for various studies of solar wind properties. This program is supervised by Dr. Alan J. Lazarus.

Solar wind data are also being routinely received and analyzed from the Voyager 2 spacecraft, which is now well beyond the orbit of Saturn. Voyager 2 flew past Saturn in August 1981, and will encounter Uranus in January 1986. Preparation of detailed plans for the measurements to be made at Uranus has begun

during the past year and will continue during 1983 and 1984. If the spacecraft is still operational at that time, NASA plans to direct it to an encounter with Neptune in August 1989. Professor Herbert S. Bridge is the Principal Investigator for the Voyager Plasma Experiment. Professors John W. Belcher, Stanislaw Olbert, Ralph McNutt and Drs. Alan Barnett and Paul Gazis are involved in mission operations and data analysis.

An Ion Mass/Velocity Spectrometer for the Mission to Halley's Comet (Giotto)

The objectives of this investigation are to study the physical and chemical processes occurring in the ionospheres of comets and to understand the interaction of comets with the solar wind. The European Space Agency (ESA) has authorized a mission to Halley known as the Giotto Mission. The investigation is now under the leadership of Professor Johannes Geiss of the University of Bern. Limited funding has been made available by NASA for US investigators on this mission, and a group led by Dr. Marcia Neugebauer of the Jet Propulsion Laboratory submitted a successful proposal. Dr. Lazarus and Professor Bridge are Co-Investigators.

Physics of Space Plasmas in the Earth's Magnetosphere and Ionosphere

In August 1979, a program of theoretical research on the physics of the terrestrial magnetosphere and ionosphere was initiated under sponsorship of the United States Air Force. These studies apply the basic kinetic theory of charged particles moving in a magnetized environment to problems in weak and strong plasma turbulence, plasma instabilities, and collective effects on wave-particle interactions. The specific phenomena considered in this research program include: diffuse, discrete, and flickering aurora; magnetic merging and reconnection in the magnetotail, in particular the relationship of these phenomena to the onset of magnetic substorms; the origin of the auroral kilometric radiation; the formation of non-Maxwellian ion and electron distributions; VLF whistler modes; lower- and upper-hybrid instabilities; the trapping and precipitation of energetic charged particles; plasma processes near the Earth's bow shock; and beam plasma interactions and ballooning modes in the low-latitude ionosphere. Drs. Tom S. Chang and Geoffrey Crew and Professors Bruno Coppi and Olbert are involved in this program.

In February 1983 an experimental program also under Air Force sponsorship was initiated to study the plasma environment encountered by a space shuttle in polar orbit. This work is being carried out by Dr. Joseph H. Binsack and Professors Bridge, Belcher, and Olbert.

PLANETARY STUDIES

Venus Radar Mapper (VRM)

The main purpose of this new NASA mission to Venus (formerly the Venus Orbiting Imaging Radar Mission - VOIR) is to map the surface of this cloud-shrouded planet using a Synthetic Aperture Radar (SAR). The data from the radar will be processed into mosaics to yield a global map of the planet at approximately 300-meter resolution. This map will be used to describe and locate the major geological regions in an attempt to understand the processes that have shaped the surface of Venus and led to the evolution of its distinctive atmosphere.

Professor Gordon H. Pettengill of the Department of Earth and Planetary Sciences is the Principal Investigator of the SAR. The VRM is currently planned by NASA as a new start in October 1983 with the launch scheduled for spring 1988.

SPACELAB VESTIBULAR EXPERIMENTS

This program, being carried out under the direction of Professor Laurence R. Young of the Department of Aeronautics and Astronautics, will provide a series of experiments to test theories of human reaction in the gravity-free environment of space. The Center furnishes management and engineering support for the program.

Two sets of flight equipment have been delivered to NASA for the Spacelab-1 mission (SL-1). Astronaut training is currently in progress with this equipment, which is scheduled to fly in September 1983. Upgraded versions of these vestibular experiments were selected to fly on the German D-1 Spacelab mission (launch scheduled in June 1985) and the NASA Life Sciences Spacelab-4 mission (scheduled for December 1985). During the past year, CSR has negotiated contracts for both of these missions. For each mission, seven separate experiments are planned, some in collaboration with Canadian and European Space Agency

investigators. The experiments range from the measurement of various responses to head motions, to hopping experiments which will test otolith changes during weightlessness. Memory/disorientation experiments and motion sickness susceptibility experiments will be conducted to provide an understanding of the problems experienced by astronauts in the Apollo, Skylab, and Space Shuttle missions. Professor Young is assisted in these Spacelab experiments by Drs. Charles Oman and Byron Lichtenberg of the Department of Aeronautics and Astronautics.

DETECTOR AND INSTRUMENT DEVELOPMENT

X-ray Spectrometry

Two programs are being carried out under Professors Canizares and Clark to develop new techniques of moderate to high resolution spectrometry for the NASA Advanced X-ray Astrophysics Facility (AXAF) and other future missions. One is to design an improved version of the Bragg crystal spectrometer that was flown on HEAO-2 (the Einstein Observatory). New curved crystal geometries that will achieve higher spectral resolution have been derived, and crystals are being cleaved, bent, and tested in the laboratory. The second program, a collaboration with Professor Henry Smith of the Electrical Engineering and Computer Science Department, involves the development of thick, high spatial frequency X-ray transmission gratings. Work carried out by Mark Shattenburg in the Microfabrication Laboratory of the Center for Materials Science and Engineering has yielded gold gratings with 0.2μm period and 1μm thickness. The 10:1 aspect ratio of the gold lines are the highest ever achieved in microstructures of this kind.

X-ray CCD Camera

Development of a spectroscopic X-ray photon camera for flight on the NASA AXAF has been the central goal of Dr. Ricker and his colleagues since the MIT CCD development program was initiated in 1975. During 1982, several important successes were achieved in this program. Some were the culmination of several years of incremental improvements, while others were due to technical innovations made during 1982 and 1983. Throughout this program, there have been substantial benefits from the synergistic effect which the closely-coupled X-ray and optical CCD (e.g., the MASCOT) development programs have produced at MIT.

During the past year, we brought into routine operation a general purpose CCD test system based on a novel, high-speed, microprocessor-controlled clock generator coupled to a new, low-cost "generic computer" (described below). This system is being used to search the multi-dimensional space of clock parameters (including clock amplitudes, duration, leading and trailing edge shapes, etc.) for conditions of optimal low-noise performance of CCDs with a variety of fabrication geometries. Among the devices tested were "virtual phase" CCDs possessing both thick and thin substrates, as well as those with coated and uncoated gate structures.

Extensive test and evaluation of a triple correlated sampler, invented in early 1982 by Doty and Ravel, have demonstrated a high degree of effectiveness in reducing a variety of noise contributions for which the traditional double correlation method is ineffective. Refinement of the ultra low noise ($\lesssim 1.8$ on nV $Hz^{-1/2}$) MIT off-chip preamp, also developed by Doty and Ravel, continued. Substantial improvement in linearity has been attained through increased feedback without loss of its "near-theoretical" low noise level.

A collaborative agreement was reached with the X-ray group at Penn State and with the Jet Propulsion Laboratory to propose jointly an imaging CCD X-ray camera for the AXAF. The agreement facilitates an open exchange of information and assigns the camera development tasks according to the demonstrated strengths at each of the three institutions.

A replica of the MIT camera is being constructed for X-ray measurements of laser-induced plasmas at Lawrence Livermore Laboratory, in collaboration with the Laser Diagnostic Group. We are also exploring the possibility of using the MIT camera to evaluate background radiation levels in low earth orbit with a Shuttle "getaway special." As a nonastronomical instrument, the MIT camera (coupled with a grazing incidence X-ray microscope) may very well prove useful in X-ray fluorescence analysis of surfaces of laboratory solids.

MASCOT (MIT Astronomical Spectrometer/Camera for Optical Telescopes)

During the 1980-1982 period, the MASCOT (MIT Astronomical Spectrometer/Camera for Optical Telescopes) was developed by Dr. Ricker and his colleagues to permit measurements with CCD arrays from a variety of ground-based telescopes. The MASCOT was initially tested at the MIT Wallace Observatory on the 24" telescope. After the initial test runs at Wallace, extensive testing was carried out at the 52" telescope

of the McGraw-Hill Observatory on Kitt Peak. In the photometer mode, MASCOT appears to be superior to the best instrumentation currently available and used routinely on the 200" telescope at Palomar. In the spectrometer mode, MASCOT is comparable in sensitivity to the best instruments available. Using the McGraw-Hill 52" telescope, spectral measurements can be made on objects as faint as m~21, and photometric measurements can be made on objects as faint as m~24. These values are for a one-hour integration time. The development of MASCOT constitutes a real advance in modern high-efficiency photon counting instrumentation for ground-based astronomy, and has obvious applications for balloon- and satellite-borne telescopes.

In mid 1981, MASCOT became fully operational, and since that time it has been used for more than 200 nights on the McGraw-Hill Observatory 1.3 m telescope, the Cerro Tololo Interamerican Observatory (CTIO) 1.5 m telescope, and the Mauna Kea Observatory (MKO) 2.2 m telescope, as well as on the Wallace and MKO 0.6 m telescopes. Numerous astronomical discoveries were made by the approximately 100 MIT observers involved in its use during that period. Scientific results have been reported at 10 national and international meetings, and 12 papers describing MASCOT observations have been published in astronomical journals during the past 1-1/2 years. (Further details are given in the description for the Wallace Observatory and the McGraw-Hill Observatory.)

In May 1982 a computer-controlled "autoguider" facility was added to MASCOT, significantly increasing its flexibility and ease of use. In its initial use at MKO, it provided image stabilization of ~0.1 arc sec rms. Following its initial implementation on the MKO 0.6 telescope, the autoguider was successfully used in observations with MKO 2.2 m and McGraw-Hill 1.3 m telescopes, demonstrating that the design is "telescope-independent" as originally intended. Following the discovery of the 1.5 millisecond radio pulsar (PSR 1937+21), a microprocessor-controlled synchronomous scanner was constructed for use with the MASCOT to search for an optical counterpart to this object. Preliminary searches carried out during May/June 1983 are presently being analyzed, and follow-up observations with the MASCOT mounted on the 4-meter telescope at Kitt Peak National Observatory are scheduled during September 1983.

Dr. Ricker and his collaborators are presently designing a "MASCOT II" for the new 2.4 m Dartmouth/Michigan/MIT telescope at Kitt Peak. This instrument will use a mosaiced CCD (8 arrays) and will permit simultaneous red and blue area photometry to be carried out at a level of sensitivity which will rival that of the Mayall 4-meter (also at Kitt Peak). Furthermore, insertion of an appropriate dispersive element in the optical paths of the two arms of the MASCOT II will permit it to operate as a wide field, high efficiency double spectrograph.

Development of a "Generic" Image Processing Computer

During the past year, a "generic" image processing computer was developed in response to the pressing needs of data reduction and analysis for the MASCOT program, as well as the requirements for an interactive control system for the MIT X-ray CCD camera described above. The computer requirements for this system dictated that it possess a long word length (>32 bits), be able to perform integers operations at high speed (~200,000 operations per second), possess a large primary memory (>2 M bytes), support several users (>4), simultaneously, and cost less than $25,000. The closest commercially available system with the required level of performance was a VAX/750, with image processing peripherals which exceeded our cost guideline by a factor of ~8x. The approach which we chose to follow is based on a Multibus (IEEE 796) configuration, with card level systems provided by a variety of vendors. By rigidly adhering to this standard, the system we successfully configured from units provided by more than a dozen vendors has proven to be just as reliable as a single vendor, bundled system. Because of the fact that each card level unit in our computer is available from several suppliers, we have dubbed it a "generic computer." For software, we have chosen to use "industry standard" implementations of the UNIX operating system, and machine independent versions of high level compilers.

Dr. John Doty has been responsible for development of the computer. Student involvement in this program has been extensive, with six senior theses thus far being based upon various subsystems of the computer. Currently, there are two Ph.D. students (Vanderspeck and Lupino) who will be using replicas of this machine for controlling and gathering data for their dissertation research.

We have freely made the details of our machine available to other research groups. At the present time, nine other research programs have expressed interest in replicating the MIT design. Of these, four are outside MIT--Lawrence Livermore Laboratory, the University of Michigan, Goddard Space Flight Center, and the McGraw-Hill Observatory (Kitt Peak, Arizona).

FUTURE MISSIONS

The Center is involved in several NASA flight programs which vary greatly in status. Some are fully approved and have relatively firm flight dates; some are in a study phase with tentative launch dates; some are more nebulous. A partial list follows.

X-ray Timing Explorer

This is a new NASA X-ray astronomy satellite program which has been proposed for the late 1980's and early 1990's. The main objective is to study the time-variability of celestial X-ray sources on a wide range of time scales from milliseconds to years. In the fall of 1982, a Center group under Professor Bradt was selected to participate in mission studies and development. The MIT group is participating in this project as an equal partner in a collaboration with the X-ray astronomy group at the NASA/Goddard Space Flight Center. The MIT group will have primary responsibility for the Scanning Shadow Cameras, which serve as X-ray all-sky monitors, and the On-Board Data System, which is a sophisticated on-board electronics/microprocessor package designed to handle the large data flow from the GSFC Proportional Counter Array, a large area set of X-ray detectors. The MIT science and engineering studies are under the supervision of Dr. Levine.

Reflectance Spectrometer Research for Possible Inner Solar System Planetary Orbiters

The Center is conducting preliminary design and breadboard development of a reflectance spectrometer instrument (RSI) to demonstrate the capability of an optical/IR spectrometer of moderate resolution, in order to determine the composition of material of solar system bodies by studying their reflectance spectra. In addition, by incorporating detectors in the direction perpendicular to the spectral dimension at the focal plane, spatial information is simultaneously obtained for several selected wavelengths. Detector evaluation is continuing, as well as optical and electronic design, so that a specific instrument can be designed readily for a potential planetary or asteroid mission. A ground-based version of this instrument has been fabricated at CSR and is currently being tested prior to delivery to the University of Hawaii, for evaluation using ground-based telescopes there. The research program is under the scientific direction of Professor Thomas B. McCord of the University of Hawaii. Supervision of the technical program at MIT is provided by Dr. Joseph H. Binsack of CSR.

Orbiting VLBI Network Utilizing the Space Shuttle and Other Satellites

This research program, under the direction of Professor Bernard F. Burke of the Department of Physics, is to investigate the concepts and methods of implementation of an orbiting Very Long Baseline Interferometer (VLBI) terminal in space. Earlier investigations concentrated on small antennas fixed-mounted inside the Shuttle. Current concepts will draw on other NASA studies of large deployable antennas of 50-100 meter diameters. Antenna-pointing accuracies, stability and dynamics, RF feed configurations, and data-handling techniques are being investigated by MIT in conjunction with the Marshall Space Flight Center and the Jet Propulsion Laboratory. Possible international collaborative projects are also being investigated and a workshop on Orbiting VLBI is being planned for Summer 1984. Professor Burke is assisted by Professor David Roberts of Brandeis University.

Origin of Plasmas in the Earth's Neighborhood (OPEN)

The OPEN program consists of a series of four satellites at various positions in the Earth's magnetosphere which monitor its response to changing conditions in the solar wind. These solar wind conditions are recorded by another satellite, the Interplanetary Physics Laboratory (IPL), at the libration point upstream of the magnetosphere. A plasma experiment proposed jointly by the Goddard Space Flight Center and MIT has been selected for this program and preliminary design is in progress.

HERBERT S. BRIDGE

Cell Culture Center

The Cell Culture Center at MIT has been established and funded by the Human Cell Biology Program of the National Science Foundation. It is intended to serve as a facility and resource for cell biologists throughout the United States.

The Center is headed by Professor Phillips W. Robbins of MIT, principal investigator, and Donald J. Giard, director. The mission of the Center is to produce cells and viruses on a large scale in order to allow scientists to conduct novel and important experiments in basic cell biology that could not be accomplished with the materials and resources in the investigator's own laboratory. The Center is working directly with individual scientists on basic research problems and, in addition, is conducting an active program in the development of new techniques for large-scale cell and virus production.

Production

During the period July 1, 1982 to June 30, 1983, the Cell Culture Center provided cells and/or virus material to 32 research groups throughout the United States. Cells are routinely produced either in suspension culture or as roller bottle cultures. During this period, the demand for suspension increased substantially over the preceding year resulting in approximately a two-fold increase in total cells produced (approximately 10^{13} total cells). Examples of projects completed during the past year include:
1440 roller bottles (RB) of SV-80 cells for the University of Illinois in Urbana
240 liters of BRL-3A conditioned medium for Syracuse University
450 liters of HPB-ALL cells for the Dana-Farber Cancer Institute
600 liters of HeLa S-3 cells for MIT.
Other projects included the production of 50 mgs of MuLv for the University of Washington,
100 RB of SCC-13 cells grown on irradiated Balb 3T3 cells for Harvard University, and
360 RB of SV-BHK cells for Wayne State University.

Cost Apportioning Policy

The Cost Apportioning Program continues to be a successful operation. Under this program, users are required to help pay for the cost of producing their cells. Until recently they were asked to pay only for the cost of consumable materials. Recently, the policy was revised so that effective July 1,1983 users were also required to pay for approximately 18 percent of the Center's labor costs. The Center receives almost 100 percent return on all materials and services billed.

Cell Sorter Laboratory

The Cell Sorter laboratory was established several years ago as a discrete element of the Cell Culture Center, and is available for analytical and cell separation use by members of the local research community. The cell sorter instrumentation is designed to analyze various light scatter properties and any compatible fluorescent label on a rapid, single-cell basis providing statistical quantitation of each desired parameter on a given suspended cell population. The laboratory is equipped with Ortho Diagnostic System Instrumentation and an on-line computer system for data acquisition,storage, and analysis.

During the past year the Cell Sorter Laboratory worked on twenty-four projects with investigators throughout the greater Boston area. Examples of projects include:
1) analysis of T-lymphocyte antigen receptor using hybridoma antibodies with indirect FITC label
2) use of ICP22 for cell cycle analysis of human tumor populations
3) DNA analysis on a periodic basis using propidium iodide
4) analysis of megakaryocytes on the basis of ploidy following induction by the glycoprotein thrombopoietin.

Research and Development

Most of the research and development efforts at the Center have focused on the development of an improved microcarrier system for the large-scale production of animal cells and their products. Following the development of the microcarrier system by Levine et al studies were conducted to examine a number of potential applications of micocarriers, including the large-scale production of viruses and fibroblast interferon. The most productive studies involved the optimization of conditions for interferon production and culminated in the development of a highly improved, low-cost method for producing human interferon.

During the current period some important achievements were made in the area of microcarrier scale-up technology including:
1) the development of a method for removing cells from microcarriers. This has essentially solved the problem of bead-to-bead transfer, and has greatly enhanced our capability for scaling-up microcarrier culture
2) the development of an improved method for oxygenating cell cultures
3) the development of a perfusion system which has resolved some of the problems associated with high density microcarrier culture.

Projects which are in progress will continue through the next fiscal year include:
1) engineering aspects of tissue culture
2) production of interferon by CHO cells containing multiple copies of a human interferon gene
3) oxygen transfer in tissue culture systems
4) computer control of hybridoma cells in microcapsules
5) continued studies on the biochemistry of high density mammalian cell cultures.

PHILLIPS W. ROBBINS

Clinical Research Center

The Clinical Research Center (CRC) is an Institute resource established for the support and care of subjects participating in research studies conducted by MIT investigators and their collaborators. Its purpose is to facilitate and enhance research in human health and disease under optimum conditions of care. The past year continued to be highly productive for the CRC. Research studies conducted at the Center involved 2311 inpatient days and 882 outpatient visits under 35 different research protocols. More than 72 scientific articles were published or accepted for publication as the result of work associated with the Center. Bed occupancy averaged 69.3%. MIT departments using the CRC include Nutrition and Food Science, Chemical Engineering, Mechanical Engineering, Biology, Psychology and the Arteriosclerosis Center. The CRC's wide variety of research protocols and multiple observations per patient continue to place heavy demands on its specialized computing facility.

The CRC has continued under the direction of Nevin S. Scrimshaw, Ph.D., M.D., program director; William Dietz, M.D., Ph.D., assistant program director; John Udall, M.D., Ph.D., assistant program director; and Robert A. Hoerr, M.D., Ph.D., assistant program director. Michael F. Holick, Ph.D., M.D. was appointed associate program director in September, 1982. Marion Wasserman assumed the position of administrator in April, 1983.

Research training is an integral part of the research program conducted at the CRC. Physicians participating in the Clinical Nutrition Training Program offered by the Department of Nutrition and Food Science, in collaboration with five area hospitals, utilize CRC facilities to initiate new research protocols and participate in ongoing projects supervised by senior investigators and faculty. Over the past year 16 physicians representing the specialities of internal medicine, surgery, pediatrics and obstetrics/gynecology have been active in the program. Five of these physicians have been supported by a continuing training grant from the National Institutes of Health (NIH). Their research interests include adolescent obesity, exercise and diet, total parenteral nutrition for premature infants and the effect of early nutrition on gastrointestinal development. Following their training, physicians in this program have entered clinical departments of medical schools or hospitals where they have been responsible for developing effective programs in training, research and patient care. Several recent graduates of the program have remained in the Boston area and have continued their research programs in collaboration with area hospitals and the MIT CRC.

The CRC also provides research support to visiting physicians and scientists, including a number of fellows in the World Hunger Program of the United Nations University (UNU). Over the past year, UNU fellows from Lebanon, Argentina, Turkey, and the People's Republic of China were actively involved in studies at the CRC.

A wide variety of investigators utilize the CRC. For example, studies under the direction of Professor Vernon Young have continued to explore protein and amino acid metabolism in healthy adult subjects and its response to dietary factors. Using stable isotope tracers, Professor Young has demonstrated that mechanisms associated with the maintenance of body homeostasis are linked to the amino acid and protein requirements of the individual. These methods promise an increased understanding of human amino acid requirements under varying conditions of health and disease.

Dr. Holick continues to investigate the photobiochemistry of the events that lead to the formation of vitamin D in human skin. He has found that during minimum exposure to sunlight, provitamin D_3 is converted to previtamin D_3. Once formed previtamin D_3 slowly converts in the skin to vitamin D by a temperature dependent process. During excessive exposure to sunlight, previtamin D_3 is converted to two biologically inactive photoisomeres. It was concluded that the photochemistry of provitamin D_3 is the most important in regulating the sun-mediated synthesis of vitamin D_3 and is an explanation for why individuals who receive excessive exposure to sunlight do not become vitamin D intoxicated. An analysis of provitamin D_3 content in human epidermis has revealed that aging significantly decreases the ability of the skin to produce vitamin D. Studies involved in determining the evolutionary origin of vitamin D have revealed that most, if not all living organisms exposed to sunlight have the capability of photosynthesizing previtamin D. Dr. William Dietz has concluded one major series of studies regarding the metabolic interrelationships that occur in obese adolescents in response to hypocaloric diets. Studies of the optimal diet for weight reduction in this population have been rare. Dr. Dietz's studies represent a novel application of stable isotope technology under rigorous experimental conditions to a widespread and significant public health problem. Dr. John Udall has continued his studies of gastrointestinal development. He has shown in studies of animals and humans that the gastrointestinal tract of infants compared to that of adults is less efficient in digesting macromolecules, and allows the increased transport of potential antigens and toxins across the intestine early in life.

A major area of collaboration between CRC investigators has been the association between the neuroendocrine division of the Department of Nutrition and Food Science and the Department of Psychology. This collaboration has been a consequence of the convergence of the research interests of the two groups. Drs. John Growdon and Richard Wurtman (Nutrition) have continued their basic studies of the amino acid precursors of neurotransmitters. Likewise, Dr. Suzanne Corkin and her investigators (Psychology) have extended their studies of brain injury in World War II veterans and amnesics to patients with cingulotomies and craniopharyngiomas. Because the neuroendocrine division was interested in the effects of administration of neurotransmitter precursors in patients with conditions such as Alzheimer's disease, and because the Psychology Department had developed unique and highly specific tests to measure cognitive function and memory, collaboration in several studies of Alzheimer's disease has resulted in a comprehensive approach to this disorder.

Biomedical developments in the basic science departments at MIT continue to find a base for preliminary human trials at the CRC. The most recent achievement in this area is the development by Dr. Padmakar Lele (Department of Mechanical Engineering) of a focused ultrasound device to generate hyperthermia. Preliminary studies of the application of focused hyperthermia to the treatment of cancer were done in the CRC, and an extension of these studies has been funded by NIH. Hyperthermia of tumors, in combination with radiation or chemotherapy, appears to be a promising technique for the treatment of cancer.

NEVIN SCRIMSHAW

George Russell Harrison Spectroscopy Laboratory

The George Russell Harrison Spectroscopy Laboratory is engaged in fundamental and applied research in modern spectroscopy for the purpose of advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids. Techniques include the use of lasers and high-resolution spectrometers.

An interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among members in the various disciplines of science and engineering. This past year, there has been participation from several MIT departments including Chemistry, Physics, Biology, Electrical Engineering and Computer Science, Chemical Engineering, Mechanical Engineering and Architecture. Outside collaborations with Harvard Medical School and Boston University, Bell Laboratories, and several other nearby academic and industrial organizations have further strengthened the interdisciplinary research activities of the Laboratory.

MIT Regional Laser Center

The Regional Laser Center, a National Science Foundation Regional Instrumentation facility housed in the Spectroscopy Laboratory, is now in its fourth year of operation. The Center enables researchers from academic, industrial, and other types of institutions to pursue research in broad areas of laser spectroscopy and dynamics, to develop new types of coherent sources and techniques, and to perform diagnostic studies of various substances and materials. Its unique facilities, which include a broad range of lasers and ancillary equipment, constitute one of the largest and best-equipped centers devoted to spectroscopic research. They are made available free of charge to qualified scientists and engineers from MIT and outside organizations. Professor Michael Feld, Department of Physics, is director of the Center; Professor Jeffrey Steinfeld, Department of Chemistry, is its scientific coordinator; and Dr. Ramachandra Dasari is project coordinator. Dr. Peter Pappas is managing scientist.

Current available equipment includes continuous wave (CW) and pulsed dye lasers in the visible and near ultraviolet, CW and pulsed CO_2 lasers, a tunable diode laser spectrometer, and a laser Raman spectrometer. All are interfaced with microcomputers which control experiments and collect and analyze data. Auxiliary equipment includes a transient digitizer and an optical multichannel analyzer (OMA) and digital read-out. Up to the present 108 projects have been initiated at the Center in atomic, molecular and solid state physics (23); physical and inorganic chemistry (32); biochemistry and biology (20); medical science (13); and engineering and applied sciences (20). 46% of these projects have been originated by MIT Core and other faculty, 41% by researchers from other academic institutions, and 13% from industry and government laboratories. Scientists from Brazil, Argentina, China, India, Canada, and Israel have worked at the Center. Results of these projects have been published in 75 papers and conference reports and 14 theses.

RESEARCH HIGHLIGHTS

Professors Richard Lord and Gregory Petsko of the Department of Chemistry have investigated the structure of Hayfever-associated allergen Ra5, a small disulfide-rich protein, from two species of ragweed. They found that the two structures differ substantially, despite partial sequence homology and cysteine location. These differences are expected to be related to antigenic activity, as the two forms of Ra5 do not immunogenically cross-react. Many aspects of this work were performed in conjunction with Dr. Lawrence Goodfriend of Royal Victoria Hospital, McGill University, Montreal, Quebec.

Professor Mark Wrighton and Dr. William Smothers of the Chemistry Department have investigated application of transient Resonance Raman techniques to the characterization of short-lived intermediates in excited state electron transfer and proton transfer reactions of transition metal complexes. Studies of the excited state electron transfer quenching of $Ru(2,2'\text{-bipyridine})_3^{2+}$ and $ClRe(CO)_3(2,2'\text{-bipyridine})$ by N,N-dimethyl-4,4'-bipyridinium, MV^{2+}, using both pulsed and cw excitation have permitted detection of the reactive $MV^{+}\cdot$product. At present, excited state proton transfer in $(2,2'\text{-bipyridine})_2\ Ru(4,7\text{-}(OH)_2\text{-}1,10\text{-phenanthroline})^{2+}$ and $(1,10\text{-phenanthroline})_2\ Ru(4,7\text{-}(OH)_2\text{-}1,10\text{-phenanthroline})^{2+}$ is under investigation.

Professor William Orme-Johnson and Dr. Marc Walters of the Chemistry Department and Dr. Yuan-Yan Liao of the Xiamen University, China have conducted a resonance Raman study of the iron protein of Azotobacter vinelandii nitrogenase. With this technique a shift is observed in the frequency of the totally symmetric stretch of the Fe_4S_4 (S-cys)4 cubane structure as a function of protein oxidation state and MgATP binding. The frequencies observed are $335cm^{-1}$ (reduced protein), $339cm^{-1}$ (reduced protein, MgATP bound), and $342cm^{-1}$ (oxidized protein). The overall bond strength of the Fe_4S_4 core is evidently greatest for the oxidized protein. MgATP binding likely causes a compression of the reduced cube forcing it to assume the oxidized state conformation; resulting in a negative shift in the redox potential.

Professor Stephen Lippard of the Department of Chemistry has recorded resonance Raman spectra of a μ-oxo-μ-bis (acetato) bridge diiron(III) complex, which has proved to be an excellent model for the active site of hemerythrin, the marine invertebrate oxygen carrying protein. The spectra compare well with those previously recorded for the protein, and the excitation profiles also appear to be similar. Studies in progress include determination of the polarization ratios and ^{18}O isotopic substitution experiments to complete the assignment of the Raman spectral bands associated with the Fe-O-Fe moiety of this model compound. Related work is planned for models of the closely related enzyme ribonucleotide reductase.

Professor Robert Field and Dr. Steven Rice of the Department of Chemistry and Professor Colan Linton of the University of New Brunswick, Canada have been engaged in the high resolution spectroscopy of diatomic molecules. Studies include Doppler-free spectroscopy of metastable CaO, selectively detected fluorescence spectroscopy of CeO, PrO, EuO, HoO, YbO and LaF, and direct observation of spin-forbidden transitions in MgO. The rare earth experiments have demonstrated the power of Ligand Field Theory to predict and relate disparate electronic structural properties of most diatomic molecules. The CaO and MgO experiments have demonstrated some unusual fine structure population distributions which persist at surprisingly high pressure.

Professors Field and James Kinsey of the Department of Chemistry, Dr. Maurice Lombardi of Universite Scientifique et Medicalede Grenoble, and Professor K. Keith Innes of SUNY Binghamton have been conducting stimulated emission pumping studies of the acetylene electronic ground state and Zeeman and Stark quantum beat studies of excited singlet-triplet interactions. This has resulted in an unprecedentedly complete characterization of the low energy portion of the acetylene ground state potential surface and, at higher energy, to the first evidence for the existence of "quantum chaos". The quantum beat experiments are obtaining information about the dissociation energy of acetylene and about the hitherto uncharacterized lowest triplet states.

Professor Steinfeld and his colleagues have set up a Coherent Anti-Stokes Raman Spectroscopy (CARS) apparatus. The second harmonic of a high-power Nd:YAG laser beam and a tunable dye laser beam, combined in the sample of interest, generate a CARS beam colinear with the two pump beams. A computer is used to retrieve the integrated intensity of the CARS signal, calibrate the frequency difference between the dye and second harmonic laser beams, and normalize for pulse to pulse variation in the laser intensity. This apparatus is being used to measure decay kinetics of vibrational excitation in low-pressure gases. A CO_2 laser pulse populates excited vibrational states in small polyatomic molecules such as SF_6, and the synchronized CARS measurement is used to probe population in various vibrational levels following the excitation pulse.

Professor Daniel Kleppner of the Department of Physics is carrying out a detailed investigation of level anti-crossings and resonance lineshapes of the lithium Rydberg spectrum in strong magnetic fields. Preliminary studies have utilized two stabilized cw dye lasers, a superconducting magnet, and an atomic beam apparatus. The ultimate objective is to discover an approximate dynamical symmetry, analogous to the exact dynamical symmetry which exists for the hydrogen atom in an electric field.

Professors Irwin Pless and Elizabeth Hafen and Dr. Padmanaban Haridas of the Department of Physics and Professor Stephen Benton of the Department of Architecture have demonstrated the possibility of redisplaying with 40 μm resolution holograms of 40 μm objects in a volume of $1m^3$. These are recorded by Professor T. Kitagaki's research group at Tohoku University in Japan, and by this research group at the Regional Laser Center. This demonstration is a necessary first step in the design of a measuring machine for holograms of a $1m^3$ freon bubble chamber used to discover the as yet undetected tau neutrino.

Professor Feld and Drs. Dasari, Pappas, and John Thomas, all of the Spectroscopy Laboratory, and Dr. Zhu Xiwen, a visiting scientist from Wuhan Institute of Physics, China, continue their research on laser-induced nuclear orientation, in which laser optical pumping is used to orient nuclei of atoms in a vapor cell. A new technique to achieve complete Doppler coverage with single mode laser radiation has been demonstrated, using velocity changing wall collisions which do not depolarize the atoms. An experiment to measure isomer shifts and nuclear moments in an isomeric state of the Rb nucleus by monitoring the anisotropy of the emitted gamma rays is also under way. Aspects of this work have been done in collaboration with Dr. Daniel Murnick of Bell Laboratories and Dr. Charles Holbrow, a visiting professor on sabbatical from Colgate University.

Professor Feld and Drs. Thomas and Dasari have developed a high resolution infrared double resonance spectrometer with a CO_2 laser pump and a tunable diode laser probe. This apparatus has been used in cw and transient modes to study energy storage and transfer processes in CH_3F. Velocity conserving J-changing collisions (up to $\Delta J=6$), vibrational exchange collisions which populate the manifold of K states, and vibrational decay have all been studied.

Professor Feld and Dr. Thomas have studied coherence-preserving collisions for optical radiator-perturber scattering by means of sensitive velocity selective photon echo technique using ytterbium atoms as heavy long lived two level radiators. These experiments have established the quantum diffractive nature of the radiator velocity changes by demonstrating quantitative agreement with calculations. The velocity dependence of the total cross-section for radiator perturber scattering has also been measured and indicates that quantum mechanical the Van derWaals interaction is dominant in this system. Part of this work was done by Luis Spinelli, a research engineer in the Spectroscopy Laboratory on leave from the Centro de Investigacines en Laseres y Applicaciones in Buenos Aires.

Professor Feld and Dr. Thomas are investigating transverse effects in the superfluorescence of a sample of excited rubidium atoms using dye laser excitation. These experiments should clarify several outstanding questions in the theory of superfluorescence, and provide a measure of the transverse coherence properties of superfluorescent pulses.

Professor Feld and Dr. Carter Kittrell of the Spectroscopy Laboratory, Dr. Barry Sachs of Beth Israel Hospital, Drs. John Kramer, Floyd Loop and Ross Garrity of Cleveland Clinic and Mr. Lester Wolfe (New York City) are developing a system for treatment of atherosclerosis using laser light. *In vitro* tissue removal of both plaque and healthy tissue in wet and dry fields has been demonstrated using cw argon and krypton ion laser light delivered through an optical fiber. Also, it has been shown that ten nanosecond pulses delivered by lenses from a pulsed Nd:YAG laser readily cuts through heavily calcified plaque. Several of the parameters for the laser-tissue interaction have been determined. A prototype optical fiber system for use with a catheter is under development.

Professor Alexander Rich and Drs. Andrew Wang and Toshio Hakoshima of the Biology Department have discovered that oligonucleotides with the sequence d(CGTACG) will crystallize in the form of double helical Z-DNA fragments when there are methy groups or bromine atoms attached to the cytosine C5 position. The crystal structure of the brominated and methylated hexamers has now been solved and refined. Solution of the crystal structure makes it possible to visualize the manner in which AT base pairs fit into the Z-DNA double helix. The crystallographic study reveals that AT base pairs can form Z-DNA but it provides structural reasons for the fact that the AT base pairs are less stable than CG base pairs in the Z-DNA form.

MICHAEL FELD

Laboratory for Nuclear Science

The Laboratory for Nuclear Science (LNS) provides support for research by faculty and research staff members primarily in the fields of basic nuclear and elementary particle physics, including the activities of the Center for Theoretical Physics in these fields. It also supports some projects involving application to other fields of experimental techniques developed in its primary activities. It provides a computing facility for its program. The primary experimental programs are in three areas: the largest effort is in intermediate energy nuclear physics, centered at the Bates Linear Accelerator in Middleton, Massachusetts. The second area is high energy physics, with major projects at Fermi National Accelerator Laboratory (FNAL) in Batavia, Illinois; at the European Center for Nuclear Research (CERN) in Geneva, Switzerland; at the Stanford Linear Accelerator Center (SLAC) in Palo Alto, California; and at the German Electron Synchrotron Laboratory (DESY) in Hamburg, Germany. The third field is heavy ion physics with activities at Brookhaven National Laboratory (BNL) and Oak Ridge National Laboratory (ORNL).

Intermediate Energy Nuclear Physics

The principal activity in this field is centered at the Bates Linear Accelerator, which functions under the direction of Professor Peter T. Demos. This accelerator has become the national facility for intermediate energy nuclear physics,where a major experimental program to study the properties of the atomic nucleus, using intermediate energy electrons and photons to generate a wide variety of reactions, is underway. MIT faculty and Bates staff physicists, and some 107 user physicists (91 domestic, 16 foreign) from 35 other universities and laboratories in the US, Canada, Japan, and Europe, are presently engaged as initiators or collaborators in 47 active experiments there. Twenty-eight MIT graduate students were associated during the past year with the intermediate energy nuclear physics programs.

The intermediate energy program at MIT continues to center about electron scattering experiments using the Bates high-precision electron scattering spectrometer. This unique spectroscopic facility is being applied intensively to a majority of the more than 40 experiments authorized for performance at Bates. The other experiments are directed primarily to studies of photon-induced pion and proton-emitting reactions. These are now being carried out with new facilities in the Laboratory's recently completed second experimental hall.

Further developments which will extend both the accelerator's research domain and, together with the new experimental hall, its ability to meet the increasing requirements of users, are in progress. Work has been completed on a beam recirculation system which increases the maximum beam energy to 750 MeV. Experiments which utilize these higher energies are now in progress. Also being developed, in collaboration with Yale University physicists, is a polarized electron beam source, which will open a new area of experimental investigation.

Another group in intermediate energy nuclear physics is collaborating with physicists at the BNL in a study of hypernuclei using a separated K meson beam in order to investigate the binding of Λ particles in nuclear matter. Data have been obtained which have allowed detailed comparisons with nuclear model calculations. This group is also exploring jointly with physicists at Bell Laboratories the feasibility of constructing a detector which would measure both the flux and spectrum of low energy solar neutrinos.

Experimental High Energy Physics

During the fiscal year 1983, the Electromagnetic Interactions (EMI) group has continued taking data with a large detector at PETRA, the e^+e^- colliding beam device at DESY. This experiment has confirmed quantum electrodynamics down to distances of 2×10^{-16} cm; has found evidence for the existence of the gluon in three-jet events; and has measured the quark-gluon coupling constant. Measurements are being made of asymmetries produced by the electromagnetic and weak interference in the production of muon pairs. Work is continuing on the search for new leptons and new particles, analogous to the J, but made of heavier quarks, at the higher beam energies that have been made available in 1983. The group is also leading a large international consortium in the construction of a huge detector to be employed at LEP, the 50 GeV on 50 GeV e^+e^- colliding beam facility being built at CERN.

The Accelerator Physics Collaboration (APC) group continues its program at FNAL to study mechanisms of high energy reactions by means of a bubble chamber and other detectors. They play the leading role in a consortium of United States and European teams which exploits a "hybrid" detector system designed by them and being used in a major experiment which obtained over one million bubble chamber pictures in 1982. They are also collaborating in the development of a new type of bubble chamber and a holographic photography system to be used at the 1000 GeV Tevatron being constructed at FNAL in a search for new type of neutrino associated with the tau lepton.

The Counter Spark Chamber (CSC) group in a collaborative effort has constructed a major new detector for high energy neutrinos at FNAL. The initial experimental program for this apparatus is the detailed study of the weak neutral currents predicted on the basis of the electro-weak theory and discovered experimentally several years ago. The first experimental run was carried out to study the nucleon structure functions associated with the neutral weak current. This detector, consisting of 350 tons of instrumented target material followed by a muon spectrometer, will be used for a continuation of these studies when the FNAL Tevatron comes into operation. The group is also collaborating in the construction of a high energy muon scattering facility at Fermilab which will be used to study nucleon structure as well as the dynamics of quark jets in nuclear matter.

Heavy Ion Physics

The study of nuclear interactions with beams of energetic heavy ions explores the properties of nuclei which have high angular momentum and high energy and can be of species far removed from the stable nuclei found in nature. Investigations of heavy-ion reaction mechanisms, particularly those leading to fusion, continue at BNL using newly developed tools, including a zero degree beam separator for fusion studies of exotic nuclei and a gamma-ray hodoscope for the study of high angular momenta. The group has constructed and commissioned a recoil mass selector for the Holifield Facility at the Oak Ridge National Laboratory, which they expect to use as a research tool in the future.

Applications of Nuclear Techniques

A group, in collaboration with groups from the Harvard Medical School, the Peter Bent Brigham Hospital, and the Massachusetts General Hospital, has been applying techniques of high energy in clinical medicine. A new detector, the mesh chamber, is being developed for three-dimensional imaging of positron emitting radioisotopes. Other projects include high pressure proportional chambers and gas scintillators for cardiac imaging and a small proportional chamber imaging system for measurements of bone mineral loss.

Another group, in collaboration with Professor Alexander Rich of the Biology Department, has developed an X-ray diffraction facility for protein crystallography based on a wire drift chamber detector originally developed at CERN. Initial crystallographic studies are now in progress.

A scanning light ion microprobe has been developed by a member of the Heavy Ion group. It is utilized by MIT faculty in chemical engineering (studying the distribution of trace elements in coal particles); biophysics (studying the changes in the distribution of elements during cataract formation); geophysics (examining volatile trace elements in meteorites); and in nutrition (studying zinc and iron levels in control and in malnourished populations).

Particle Theory

It is presently believed that the particles which are at the basis of all matter are quarks and leptons, which interact with one another through gauge fields. There is currently a gauge field theory of the strong interactions called "quantum chromodynamics" or QCD and another, the Weinberg-Salam-Glashow theory, that unifies the electromagnetic and weak interactions. Both of these theories, which agree with experiment insofar as they have been tested, and gauge theories in general, are being investigated by the particle theorists. Studies are also being made of "grand unified theories" which attempt to unify weak, electromagnetic, and strong interaction gauge theories.

The Particle Theory group has studied, on the one hand, the nearly free particle behavior of quarks in hadrons, as seen in the deep inelastic scattering of electrons and neutrinos, and on the other hand, the experimentally indicated permanent confinement of quarks in a hadron. These two aspects of properties of quarks have for years been described by two complementary phenomenological models: the parton model and the MIT bag model, respectively, which are thought to be approximations to QCD.

Some of the QCD related topics studied during the past year are the following: finite temperature QCD; computer studies of lattice QCD; a model of the QCD vacuum including a gluon condensate and its spectrum; and the effects of Twist-4 corrections in the analysis of leptoproduction experiments, including those utilizing heavy nuclear targets.

In addition, investigations have continued on (1) non-perturbative structure in field theories, especially those related to topological properties, (2) models of particles and interactions, including supersymmetric theories, (3) and new theory of cosmogenesis, "the Inflationary Universe", based on grand unification models and leading to detailed calculations of the properties and development of the very early universe.

Nuclear Theory

The nuclear theory group has addressed a wide range of problems, including the interactions of nuclei with mesonic and electromagnetic probes, the structure of nuclei spanning the periodic table, and heavy ion

reactions from below the Coulomb barrier to relativistic energies. The role of nucleon internal degrees of freedom in nuclear structure and dynamics had been a central theme.

A substantial theoretical effort directed at a microscopic understanding of nuclear static and transition densities has been motivated by the high precision electron scattering experiments performed at the Bates Accelerator. Significant progress was made in nuclear many-body theory and the time dependent theory of nuclear dynamics. These investigations, many of them based on the mean field functional integral approach, have improved our understanding of collective phenomena and have been used to describe spontaneous and and induced fission.

A variety of projects are being pursued involving a QCD description of hadrons and the forces between them within the context of the MIT bag model. The latter studies include both phenomenological approaches utilizing hadron and quark degrees of freedom at long and short ranges, respectively, and microscopic calculations of scattering phenomena with confined composite systems.

Meson-nucleus interactions are being studied in terms of isobar-nucleon hole collective doorway states, with a complex isobar-nucleus interaction potential playing a central role. The microscopic basis of the model has been elucidated and associated predictions have been tested against data.

A continuing program of inter-relating semi-leptonic weak and electromagnetic interactions in nuclear phenomena is being pursued.

Summary of Support

Participants in the various research programs during the past year amounted to approximately 400 people. This includes 50 academic staff members, 87 graduate students, and at least 45 undergraduates from MIT and other institutions. The latter were involved in senior theses, Undergraduate Research Opportunities Programs, work-study, and similar programs. There were 70 research staff members with Ph.D.'s, including visitors and guests, and 154 employees in supporting categories such as engineers, technicians, machinists, computing and administrative personnel. At least 15 Ph.D's, four M.S.'s, and three B.S.'s were awarded based on thesis research within LNS.

Support during fiscal year 1983 from the contract with the US Department of Energy (DOE) is expected to total $17,394,000. This represents an increase of about 22 percent over the preceding year (largely through increases in high energy equipment and Bates construction-type projects). This sum breaks down as follows: operations costs (salaries, wages, materials, services, travel, and overhead) were $12,807,000, of this $4,306,000 was for experimental and theoretical high energy physics, $6,835,000 was for intermediate nuclear energy physics for the support of the Bates Linac facility and program, and $1,666,000 was for nuclear structure theory, hypernuclei, and heavy ion experiments. Equipment costs totaled $3,400,000; of this, $2,400,000 was for high energy physics and $1,000,000 was for medium energy and heavy ion physics. A total of $1,187,000 will be expended for accelerator improvement, energy conservation, general plant, and construction projects associated with the Bates Linear Accelerator. Support for relatively new Laboratory programs relating to the application of high energy techniques to medical and biological problems totaled some $91,000 (primarily from the National Institute of Health). Support for other programs within LNS including support from other institutions and laboratories for collaborative work undertaken directly by LNS is expected to total about $130,000.

JEROME I. FRIEDMAN

McGraw-Hill Observatory

Since 1975, the University of Michigan, Dartmouth College and MIT have jointly operated the McGraw-Hill Observatory on Kitt Peak, near Tucson, Arizona. The present telescope has an aperture of 1.3m, which is modest by research standards. A major telescope of 2.4m aperture is presently under construction at the observatory. It will be a first-class instrument that will be used for frontier research in astronomy and for the development of advanced instrumentation. The new telescope is scheduled for full operation in January 1985. MIT observers will be entitled to one-third of the available time on both the 2.4m and 1.3m telescopes, a total of about 240 nights per year.

The demand for observing time remains very high. During the dark half of the lunar calendar, the number of nights requested exceeded the number of nights available by a factor of 2.5. During the 1982-83 academic year, two dozen MIT observing teams travelled to the observatory; half of the observer-trips were made by graduate students. The focal-plane instrument of choice for most MIT observers continues to be the CCD spectrometer/camera built by Dr. George R. Ricker and his collaborators.

The past year's research includes the following: In the X-ray astronomy group, Professor Hale V.D. Bradt and Ronald Remillard continued to identify and study the optical counterparts of X-ray sources detected by the HEAO-1 all-sky survey; new identifications include four Seyfert galaxies and one Be star. Professor Claude R. Canizares has continued a program of optical identification of quasars and active galaxies located through X-ray observations with the Einstein Observatory, and has begun to investigate the accretion of gas onto the central, dominant galaxies found in some galaxy clusters. Professor George W. Clark is engaged in a program of area photometry of faint jets and ripples in elliptical galaxies, and recently detected both phenomena in M89. Dr. Jeffrey E. McClintock and Ronald Remillard continue to search for orbital light variations among the optical counterparts of X-ray binaries. They confirmed their earlier discovery of a 7.8 hour orbital period for the X-ray nova A0620-00 and obtained extensive two-color data on this 19th magnitude object. Dr. George R. Ricker was engaged in several projects including the search for the elusive optical counterparts of γ-ray burst sources with Dr. Bradley E. Schaefer, and the search for optical pulsations from the "millisecond" pulsar (PSR 1937+214). Also, with Professor Saul A. Rappaport and John Kruper, Dr. Ricker is investigating the near infrared spectra of BL Lacertae objects.

In Professor James L. Elliot's planetary astronomy group, Professor Edward W. Dunham has made extensive observations of the Saturnian satellite Hyperion in an effort to determine its rotation period. To date he has determined that the rotation period exceeds one day and is probably not synchronous with the orbital period. Richard Baron has made several observations in support of occultation studies of Saturn and Neptune. He also carried out a thorough search for a faint ring of Saturn which was suggested by spacecraft flyby data. Dr. Linda M. French obtained spectra of three planetary satellites, Iapetus, Phoebe, and Himalia.

In Professor Bernard F. Burke's radio astronomy group, Dr. Charles R. Lawrence has continued to search for faint optical counterparts of radio sources discovered in the MIT 5 GHz survey. About 100 radio source locations have been searched for optical counterparts. This work, and subsequent optical spectroscopy on larger telescopes, should provide insight into the evolution of radio galaxies.

Within the Center for Theoretical Physics, Professor Lennox L. Cowie has obtained narrowband imaging data of the center of galaxy clusters in a study of the filamentry gas and the hot coronal gas found there. Dr. Antoinette Songaila-Cowie searched for high velocity Hα emission in the galactic halo. Dr. Stephen M. Kent obtained data on galaxies in clusters and in the field to study the effects of the cluster environment on the structure of the disks of SO galaxies.

JEFFREY E. MCCLINTOCK

George R. Wallace, Jr., Astrophysical Observatory

The George R. Wallace Astrophysical Observatory is a teaching and research observatory, located in Westford, MA. Its facilities consist of a 24-inch reflecting telescope, a 16-inch reflecting telescope, and a small building that houses a workshop, darkroom, computer, and observers' quarters.

Last fall, most of the telescope time was reserved for students in the astronomy courses. On several occasions, Dr. Linda French and Professor William Pinson conducted sessions of the observational seminar, 12S23, at the observatory. Also Professor Pinson's class, 12.113, used the 16-inch telescope. Twenty-four students in the observational laboratory course (8.287J-12.117J), taught by Professor James Elliot and Dr. French, conducted a variety of projects. Several worked on recovering asteroids whose orbits had become poorly known because of a scarcity of recent observations. Others determined the light curves of the dwarf Cepheids DY Peg and CY Aquarii. Other projects included UBV photometry of several clusters and light curves of the asteroids 9 Metis and 690 Wratislavia. Several UROP projects at the observatory were supervised by Dr. French and Professors Pinson and Elliot.

Dr. Edward Dunham and Mr. Richard Baron recorded the intensity from the star SAO during a close passage of comet Churymov-Gerasimenko, in an attempt to record an occultation by the inner coma. No decrease in light intensity was observed, which will allow them to place an upper limit on the amount of dust in the coma. During January, the MASCOT (a CCD camera-spectrometer) was installed on the 24-inch. Mr. Samuel Conner used this instrument to obtain more photometry of Hyperion, as part of our program to determine its rotation period. Mr. Alberto Sadun obtained observations of the quasar 3C273, and Mr. John McGill attempted to recover seventeen asteroids discovered earlier in the year by Mr. Gregory Aldering. Dr. Dunham and Mr. Baron used the MASCOT for high speed differential photometry of the star SAO 158412 as it passed near Saturn, behind the region corresponding to dips in the plasma intensity found in the Pioneer and Voyager data by Dr. Lazarus and his colleagues.

Improvements to the instrumentation at the observatory included a new data recording system for photometry. Currently we are working on plans for a new building to house 14-inch telescopes in order to accommodate the increased enrollments of the observing courses. Senior theses for the department of Physics, based on observations at Wallace observatory were completed by Mr. Aldering and Mr. McGill (both in the Class of 1983), under the supervision of Professor Elliot.

A generous gift from Mr. Clinton B. Ford will enable us to begin construction of a CCD camera for the 24-inch telescope.

JAMES L. ELLIOT

Vice President and Dean of the Graduate School

Annual reports for the Registrar, the Division of Comparative Medicine, and the Medical Department -- including the Environmental Medical Service -- follow the reports on the Graduate School which my associates in the Graduate Office and I have prepared. I have also included a brief statement at the end of this group of reports.

DEAN OF THE GRADUATE SCHOOL

Tables of statistical information for the Graduate School appear at the end of this section. For purposes of ready comparison with information presented in our previous reports, we present these data in formats similar to those used in past years.

For the first time in ten years, these data indicate that our total regular graduate enrollment has declined from that of the preceding year. Although this dip is small, it is, we believe, the result of the continued decline in financial support for graduate students. These discouraging trends are clearly evident in the tables which indicate the distribution of major categories of graduate support and the trends with time in real-dollar value of those categories of support. Because we are so dependent upon sponsored research support in the form of research assistantships in the two large schools - Engineering and Science - our total enrollment trends are strongly influenced by the trends in real-dollar levels of on-campus sponsored research. The latter began to fall off two years ago and now we see - delayed about a year - the corresponding fall-off in enrollment.

Traditionally at MIT, the salaries paid to research assistants have been intended to cover both tuition and modest stipends toward living expenses. Because these salaries have been charged directly to research sponsors, the effect of the year-to-year tuition increases which have generally outpaced inflation has caused the "cost" of a research assistant to a contract to approach the "cost" of full-time research associates and other post doctoral employees. Consequently, as research funds have become more limited, project leaders have begun to employ older, more experienced staff rather than student staff assistants. Thus, there has been, in effect, a dual impact on the number of research assistant positions made available - as a result in the decline in sponsored research volume and the increase in the average cost of a research assistant to the contracts.

We knew, also, that the level of these direct charges to MIT sponsored research contracts were increasingly being questioned by sponsoring agencies. Direct charges from other universities were typically lower because their tuition costs were lower (e.g., state institutions) and/or because they did not charge tuition directly to the contract (e.g., the tuition was charged to the employee benefit pool which covered the entire employee population).

Over this past year, in an effort to attack these negative impacts, we undertook to change our policies regarding the charging of research assistants and teaching assistants - from direct charging to contracts to charging to our employee benefit pool. Although our government auditing agency - the Office of Naval Research - approved this change early in the academic year, most of the remaining year was consumed in staff and faculty meetings to formulate the numerous changes in subsidiary policies and procedures which were required. On June 1, 1983, we initiated the new program; hopefully, most of the unforeseen difficulties will be discovered during the summer of 1983 to permit a smooth entrance to the fall term rush.

The mechanics of making this change result in our academic budgets having to absorb a significant increase in the benefits charged to academic salaries. We knew this would be the case at the outset of our planning but we have assumed - almost as an act of faith - that the decline in research assistants' positions will be reversed and that we will more than recoup this negative impact through the tuition income generated by the increased enrollment.

Over the past few years, I have reported on developments at the federal level related to graduate financial support. I now feel some small degree of confidence in predicting a "coming-together" of the many diverse interests - usually representing specific disciplinary or professional interests rather than entire graduate schools or all post baccaulaureate education - in efforts to articulate the importance to the national well-being of maintaining and in some cases restoring financial support for graduate education. One indication of this joining of forces is the position paper entitled "The Federal Role in Graduate Education", which began as a small white paper within the Association of Graduate Schools (AGS) and the American Association of Universities (AAU) but which now has the additional endorsement of groups as diverse as the Council of Graduate Schools in the United States (CGS) and the National Association of State Universities and Land Grant Colleges (NASULGC). The following is the Executive Summary of this paper, published January 1983:

"Graduate education includes a rich diversity of programs ranging from professional master's to research doctorate degrees. This paper focuses on the federal role in doctoral education, that part of the educational system designed to educate the researchers and scholars responsible for the discovery and dissemination of knowledge.

"The appropriate federal role in graduate education is to assure a continuing infusion into our society of talented individuals with the knowledge, technical skills and range of perceptions necessary to sustain a strong national defense, an innovative and productive economy, an intellectually and esthetically vigorous culture, and effective international leadership. The need for such talent has become all the more critical in the context of sharply increasing international competition.

"To implement its role, the federal government should act to: 1) encourage a portion of the country's most gifted students to enroll in graduate school, 2) assure that financial circumstances will not prevent promising students from enrolling in graduate programs, and 3) promote educational opportunities for talented individuals from groups underrepresented in major academic fields.

"The paper describes current federal programs of graduate student support and assesses their adequacy to meet essential federal objectives. To correct the most critical deficiencies in the existing set of programs, the following recommendations are proposed:

- a substantially expanded, balanced set of merit fellowships awarded to the most talented students and the strongest academic departments;

- continued, strong support for research assistantships as a component of the research project grant system;

- the provision of effective self-help programs, especially the Guaranteed Student Loan and College Work-Study programs, accompanied by mechanisms for reducing loan indebtedness;

- the classification of graduate students as financially independent upon enrollment, providing they meet the criteria for independence from that time forward."

Still further evidence of growing cooperation among diverse institutions and disciplines is apparent in the evolution of the so-called "COFHE Graduate Project". As I reported last year, the Institute was a prime mover in broadening the perspectives of the Consortium on Financing Higher Education (COFHE) a few years ago to include graduate programs. The COFHE Graduate Project became a multi-year effort designed to collect information and to develop policy recommendations about graduate study in the arts and sciences, the humanities and engineering. The project engaged in the study of various issues concerning application, admission, and matriculation trends, the financing of graduate education, the characteristics of the graduate population, and the condition of graduate programs. Research efforts focused on the doctoral process, but data was also collected about selected master and professional school programs.

The results of these efforts have been important to the National Commission on Student Financial Assistance (mandated by the U.S. Congress). At the request of the Commission, the COFHE group has also provided studies addressed to the following specific questions:

1. Are students dissuaded from graduate study on financial grounds?

2. What are existing and projected levels of graduate (and professional school) student borrowing?

3. Where does underrepresentation exist in graduate school participation in degrees awarded and in subsequent employment? What factors, in particular, discourage the participation of women and minorities in graduate schooling?

Participation in this Graduate Research Project has been limited to certain private universities, women's colleges and graduate departments - all part of COFHE - and three major public universities were invited to join. The success of this approach and the potential importance of expanding both participation and scope now make it appear wise to explore the "adoption" of the project by AAU/AGS (The Association of American Universities and the Association of Graduate Schools). At this writing, a planning group representing these organizations is actively exploring how such a transition might take place and what forms future governance, funding, and staffing might be developed. It appears likely that foundation funding will be made available to support the project under AAU/AGS aegis, the latter contracting with one of the member universities to conduct the actual research.

With respect to the shorter-range issues, we continue to place graduate needs before national organizations and the relevant House and Senate Committees. Although the Congress has become relatively well-schooled in undergraduate financial needs over the past decades, graduate needs have only recently begun to come into some focus. Indeed, I believe one could argue that the administration's efforts last year to curtail seriously graduate access to the Guaranteed Student Loan Program resulted in such an outpouring of graduate students and their supporters as to have raised Congress' attention level much

more rapidly than might otherwise have occurred.

For these and other reasons, I am, as I stated earlier, feeling some small degree of confidence in achieving, if nothing more, some serious national debate on federal policy on graduate education.

Despite our seemingly endless preoccupation with financial support, we have had the good fortune to engage many educational matters. During the year, the Committee on Graduate School Policy held several discussions regarding the apparent proliferation and "fine-tuning" of fields of graduate study at the Institute and of the associated designation of advanced degrees. "Academic" as such topics may appear, the conversations which surrounded them often provided striking illumination of the differences in basic educational objectives and philosophies across the disciplines which make up our graduate school.

The CGSP also recommended to the faculty the establishment of the following new degrees:

- The PhD in Radiological Sciences within the Nuclear Engineering Department
- The SM in Electronic Materials within the Department of Materials Science and Engineering
- The SM in Political Science & Public Policy within the Department of Political Science
- The PhD in Health Policy & Management - the first graduate degree to be awarded by the new Whitaker College

Subsequently, the faculty and corporation accepted these recommendations.

In addition, the CGSP attended to such housekeeping projects as minor changes in faculty regulations and significant revision in general catalog presentations of courses and subjects. Finally, the Committee attended to the pleasurable task of considering candidates for advanced degrees and recommending the awarding of their degrees in almost all cases. It also attended to the not-so-pleasurable task of finding the academic performance of a very small fraction of our graduate students unsatisfactory.

I and my colleagues in the Graduate School acknowledge with sincere thanks the assistance of the faculty members who completed their terms this year as departmental representatives to the CGSP, and we welcome their replacements:

Materials Science and Engineering
  Professor Robert W. Balluffi to Professor Bernhardt J. Wuensch
Biology
  Professor Mary L. Pardue to Professor David Botstein
Psychology
  Professor Mary C. Potter to Professor Alan V. Hein - Fall Term only
Chemical Engineering
  Professor Glenn C. Williams to Professor Robert C. Reid
Earth and Planetary Sciences
  Professor Gordon H. Pettengill to Professor Charles C. Counselman, III
Economics
  Professor Jerome Rothenberg to Professor Robert L. Bishop

KENNETH R. WADLEIGH

GRADUATE WOMEN

Ten years ago the Ida M. Green Fellowships were first awarded to five women entering their first year of graduate study at MIT. At that time (1973-74) 318 women were enrolled in graduate programs representing 9% of the total graduate student population. During this 10-year period, the number of graduate women has increased steadily and in the fall of 1982 there were 856 women in MIT graduate programs or 19% of the total graduate degree candidates (Table VIII). For the past two years, total enrollments of women students in all graduate fields of study on the national level have remained constant at 46%. During the same period, total graduate enrollment for field of study nationwide indicates increases in physical sciences (+7.2%) and engineering (+6.0%) and slight decreases in social sciences (-0.5%) and biological sciences (-1.0%). MIT's total graduate population in these areas decreased in science, including biology (-2.0%), and engineering (-2.0%) with no perceptible change in humanities and social sciences. MIT's total graduate enrollment decreased 1% from fall of 1981 to fall of 1982 (Table VIII).

Although the number of applications from women has remained pretty steady in recent years, in the fall of 1982 the number of first-year graduate women increased 10% to reverse last year's decrease in this category (-4%). Also, women accounted for the highest percentage yet of the first-year graduate students at 20% (Table VIII). This is still a long way from the 47% proportion of first-year women enrolled in graduate schools nationwide in the past two years, and reflects only slowly changing patterns for women entering graduate work in non-traditional fields like physical science and engineering which predominate at MIT.

As a further example, in the fall of 1982 applications from male students increased 4% at MIT as indicated in Table IX, and accounts for almost the entire 3% increase in total applicants from fall 1981. More specifically, in 1982 women applicants decreased in engineering (-4%), management (-8%), and science (-1%) in contrast to male applications which increased in engineering (+11%), social sciences (+14%) and science (+1%). Women reversed a 10% drop last year in applications to architecture and planning to an increase of 11%, while male applicants continue to decrease (-14%) in this area.

Another interesting 10-year comparison is the percentages of the total number of women registered in each school as shown in the following listing:

	Fall 1972	Fall 1982
Architecture & Planning	19%	18%
Engineering	15%	26%
Humanities & Social Science	16%	12%
Management	4%	13%
Science	46%	31%

Not only has a steady rise in the number of graduate women enrolled occurred, but also it is very gratifying to note that the number of degrees awarded to women continues to increase. Doctoral degrees awarded to women in 1982-83 reversed a sharp decrease last year to reach an all-time high of 72. However, the number of Master's degrees awarded to women decreased and the proportion of Master's degrees awarded to women also decreased slightly in the past year from 19% to 17.5%. The percentage of total graduate degrees awarded to women remained at 17%. No engineer's degrees were awarded to women this year (Table XI).

Nationwide, the percentage of women earning doctor's degrees in the sciences and engineering has been increasing and grew from 18% in 1977 to 23% in 1981. A 10-year span of women earning doctorates in science and engineering at MIT indicates an encouraging growth with about 4% of the doctorates awarded in 1972-73 in science and engineering going to women, 8% in 1977-78, and 13.5% in 1982-83.

FINANCIAL AID

A constant and growing concern during recent years has been with financial support for graduate students. Tuition (as well as cost of living) continues to rise with MIT projecting a 10% increase in tuition for fiscal year 1984 after a whopping 18% increase in fiscal year 1983. Women as well as men graduate students are affected. However, it is encouraging to note that more women are competing successfully in national fellowship competitions such as Hertz and NSF. Although the total number of women who receive these awards is not equal to the number of men, it is partially due to the fact that women are still in the minority in the fields of study represented by these awards. We hope that as more women are encouraged to participate in traditionally male-dominated areas so will their proportion of the awards.

On the other hand, women pursuing graduate study at MIT are supported not only as RA's and TA's in growing numbers by their respective departments, but increasingly are being sponsored by industrial fellowships such as Hughes, Bell Labs Fellowships (for employees), IBM, Shell and Chevron. Also, one of the five prestigious EXXON Teaching Fellowships at MIT is held by a woman. The few national scholarship programs specifically for women graduate students are also well represented at MIT including American Association of University Women Dissertation Fellowship, Graduate Research Program for Women sponsored by the Bell Laboratories, Xerox Special Opportunities Fellowship Program, and the IBM Fellowship Program for Women and Minorities.

As indicated in an earlier section, MIT's own Ida Green Fellowship program for entering graduate women is celebrating its 10th anniversary this fall. The six new women selected to be Ida Green Scholars for fiscal year 1984 will join 68 previous scholars who have been selected for this honor. Many have completed their degree programs at MIT and have earned 14 doctoral degrees, 25 Master's degrees (including three Master of Architecture and two Master of City Planning degrees) and one engineer's degree. Most are now pursuing lucrative careers in industry, academia, and government with a few who left MIT with Master's degrees continuing their graduate study at other universities. These women are representative of the truly outstanding caliber of women who attend MIT and most of MIT's 23 graduate departments are represented by at least one Ida Green Fellow. Therefore, it is important that we continue to encourage an even larger number of women to matriculate in our graduate school by making sure

financial as well as academic support is available to them.

In closing, I would like to acknowledge an important contribution on behalf of women graduate students, made recently at MIT. In June of 1983, the Ida Flansburgh Green Hall was dedicated. This dormitory, which actually was occupied in February 1983, provides safe, secure, on-campus housing for about 40 women graduate students. Thus, another important necessity for graduate women at MIT - additional housing - is being recognized.

JEANNE RICHARD

MINORITY GRADUATE STUDENT AFFAIRS

The national picture on minorities in graduate education is a dreary one. Although the current figures are higher than they were 10 years ago, the pattern of enrollment and degrees awarded has been on a downward slope for the past three years. The downward trend is especially alarming when you compare the degree productivity of minority member groups in science and engineering with those of women and foreign nationals.

The Scientific Manpower Commission has published a new compilation of data on the professional-level workforce in the United States, Professional Women and Minorities, 4th Edition, June 1983, with the data detailing the participation of women and minorities in the professional population. It reports the following:

"On the educational front, women are continuing their rapid progress in obtaining the education required for a professional career. Although at a somewhat slower pace, members of minority groups also are increasing their share of earned degrees. During the decade of the seventies, women earned 45% of the bachelor's, 44.5% of the Master's and 21% of the doctorates awarded. By 1981, the proportions had risen to 49.8%, 50.3% and 31.1%, respectively. Minority graduates earned 11.2% of bachelor's degrees in 1981, 10.5% of the Master's degrees and 8.3% of PhD's. Black women have higher representation in higher education relative to black men than white women relative to white men.

"Asian-Americans had the largest representation of any minority group in engineering, and they have more than doubled their share of all engineering degrees since 1973. The number of black engineers, graduating at the bachelor's level has risen from 657 in 1973 to 1,608 in 1982, while their proportion of total graduates has moved from 1.5% to 2.5%.

"Except for Asian-Americans, minorities continue to be under-represented in the physical and mathematical sciences where they earned 8.3% of the bachelor's, 6.1% of the Master's and 5.2% of the doctorate degrees awarded in 1981. However, a significant percentage of these degrees awarded, especially at the graduate level,are earned by Asian-Americans who were awarded 2.5% of the bachelor's, 2.9% of the master's and 3.4% of all doctorates awarded in these fields in 1981.

"Particularly at the graduate level, the proportions of graduates who were foreign nationals on temporary visas has grown significantly over the decade. In engineering, for example, foreign students earned 3.3% of the bachelor's, 11.9% of the Master's and 12.1% of the PhD's awarded by the United States schools in 1969. By 1982, their share had risen to 8.1%, 28.5% and 40.4% respectively. In addition to foreign students on temporary visas, significant numbers of foreign-born students are included in science, engineering and mathematics areas. Among the engineering doctoral graduates in 1981, only 50.9% were United States citizens."

The final commission report on minorities in higher education from the Higher Education Research Institute focuses on blacks, Mexican Americans, Puerto Ricans and American Indians. The aim of this study, funded in the fall of 1978 by the Ford Foundation, was to assess the educational progress made by these four groups in recent years, the factors still inhibiting their access to and success in higher education, and means by which they might achieve educational parity and full participation in society.

Data analyses found that minorities achieved substantially greater representation at all levels of educational attainment between the mid-1960's and the mid-1970's, but their representation has remained stable since that time with some recent indication of slight declines. Minority under-representation increases at each higher level in the educational pipeline, and a ratio of high attrition from secondary schools was found to be the single most important factor in under-representation in college, although all four minority groups have higher than average attrition rates at the post-secondary level.

The under-representation is especially severe in the fields of engineering, biological science, physical

science and mathematics. To achieve proportionate representation at the doctorate level, the number of minority doctorates in these fields would have to increase from four to seven fold. The most important factor in this under-representation is poor academic preparation at the pre-college level. Other significant factors include the heavy concentration of minorities in community colleges and their severe under-representation in the "flagship" public and private institutions in nearly every state.

Given the national backdrop of small numbers of minority group students coming out of high school and undergraduate schools around the country in science and engineering fields, it is no small wonder that the numbers are very low at the Master's and doctor's degree levels too. MIT has been at the forefront of major research institutions in the country in a continuing effort over the years to increase the presence of under-represented minority group members in science, engineering, architecture, urban studies and city planning, as well as economics, management and political science. The Graduate School Office has supported departmental efforts to recruit, admit, and graduate minority students as well as initiate its own activities to make MIT more accessible to black and other under-graduate minority group students.

The recruitment trips, mass mailings, utilization of faculty and administrative contacts at minority-targeted schools have been very beneficial in attracting minority graduate students. We had a 26% increase in the number of minority applications received for 1982-83 over the previous year, 264 in 1982 compared to 210 in 1981 (Table XIV). As a result of the increase in the number of applications received we ended up with a 45% increase in the number of new students enrolled in the fall of 1982. The total enrollment of under-represented minority graduate students remained relatively the same as last year, 139 vs. 140 in 1981 (Table XII).

We are very pleased to report that our minority graduates are highly sought after by industry and colleges and universities. There were a total of 51 minority degree recipients for 1982-83 with eight students receiving their doctor's degree (Table XV). Some of the doctoral degree recipients are teaching at very distinguished institutions such as Stanford, Princeton, Tufts, Virginia Polytechnical Institute, MIT, Kentucky and Wellesley, holding postdoctoral fellowships at Yale, Baylor Medical School, Washington University, and Cambridge University (England), and working as scientists at Bell Laboratory, Dupont, Xerox, IBM and General Electric Research Laboratory. Although the number of minority doctorates is small in a literal sense, MIT graduates are the largest number of minority doctorates in science and engineering in the country.

The year has been a challenging one and difficult at times but always spirited and encouraging as far as MIT's commitment to minority graduate student affairs. We would like to thank Dean Kenneth R. Wadleigh for his continuous and unrelenting support over the past eight years in our efforts to attract and retain minority graduate students. He has been a pillar of support to me as well as to all students, faculty, and staff. His leadership, wisdom and active involvement will be sorely missed by the graduate community. Dean Wadleigh has left a very positive base and legacy for the rest of us to work on. Thank you MIT for giving us Ken Wadleigh and thank you Ken for being you!

JOHN B. TURNER

REFLECTIONS

About eighteen months ago, I came to the decision that the time had probably arrived for me to seek new and different opportunities for myself and, simultaneously, in resigning from my administrative posts, to provide opportunities for one or more younger folks to bring fresh points of view to the administration of those areas for which I have had responsibility. After some discussion with Paul Gray, he and I agreed that I would round out 22 years as a senior officer of MIT on June 30, 1983. Paul also generously granted me a sabbatical year for 1983-84 to prepare for re-entry, perhaps to a faculty role in my former department.

While this is not the vehicle to publish my memoirs, I cannot close this last of my 22 annual reports to the president without acknowledging the truly wonderful opportunities that have come my way over this period. This institution always seems to provide more challenging and rewarding problems to tackle than anyone who has not experienced it can imagine. But the real key to the whole enterprise is the quality and character of the people - students, faculty, employees, staff - even presidents and corporation members.

Indeed, I believe MIT survived its most perilous financial crises in 1877, its most serious student revolts some 90 years later, and several crises in between and since, because the Institute has always been able to draw upon reserves which were carefully nurtured and built up during the good years. These were reserves of capital and plant, to be sure, but more importantly, they were reserves in human intelligence, concern, respect, tolerance and devotion - among trustees, administration, faculty, staff, students, alumni - that vast spectrum of apparently conflicting forces that make up this university "family".

In going about my tasks, I have certainly drawn upon those human reserves which were built up by my predecessors. In turn, I have tried in some small way to help to restore some of these reserves by building new "people banks" for the future. While I take some pride in the quality of the organizations I now turn over to my administrative successors, I take great pride in the many younger people - some still at MIT and many in challenging careers elsewhere - to whom I have been able to offer some assistance along the way.

To these and so many other wonderful colleagues - I thank you; I salute you; and I wish you well! In the parlance of the day, "See ya!"

KENNETH R. WADLEIGH

TABLE I

For simple comparison with data for 1981-82, the following statistical information for 1982-83 is presented in the same format. Numbers in parentheses indicate the change from 1981-82 to 1982-83.

REGULAR GRADUATE STUDENT ENROLLMENT - FALL TERM 1982

	Foreign[1]		Women[2]		Minority[3]		Total		Non-Residents[4]	
School of Architecture and Planning	146	(+27)	152	(- 5)	35	(- 6)	414	(-13)	39	(+ 1)
School of Engineering	762	(+38)	218	(-12)	56	(+ 1)	2106	(-51)	16	(+15)
School of Humanities and Social Science	93	(- 1)	103	(+ 7)	13	(+ 4)	371	(+ 3)	51	(+ 4)
Sloan School of Management	126	(+ 6)	114	(+24)	12	(+ 2)	481	(+33)	6	(0)
School of Science	282	(- 2)	265	(+14)	28	(+ 3)	1098	(-26)	28	(+14)
Health Sciences and Technology	9	(+ 3)	4	(0)	1	(+ 1)	19	(+ 2)	0	
TOTAL	1418	(+71)	856	(+28)	145	(+ 5)	4489	(-52)	140	(+34)

(1) Includes Canadians

(2) See also Table IX

(3) Includes Black Americans, Puerto Ricans, Mexican Americans, and American Indians

(4) Included in Totals

TABLE II

GRADUATE DEGREES AWARDED - 1982-83

Advanced Degrees Conferred		M.C.P., M.Arch., M.Arch. A.S.	S.M.	Engineer	Sc.D.	Ph.D.	Total
September 1982		16 (+ 3)	206 (+43)	10 (0)	14 (+ 1)	89 (+ 4)	339 (+52)
	Woods Hole			0 (0)	0 (- 1)	4 (+ 2)	
February 1983		8 (- 8)	237 (- 9)	13 (- 2)	20 (+ 2)	119 (+ 2)	403 (-13)
	Woods Hole			0 (- 1)	2 (+ 2)	4 (+ 1)	
June 1983		49 (-19)	608 (- 4)	43 (+ 6)	18 (- 9)	159 (+27)	881 (- 1)
	Woods Hole			1 (0)	1 (+ 1)	2 (- 3)	
Total		73 (-24)	1051 (+30)	67 (+ 3)	55 (- 4)	377 (+33)	1623 (+38)

Numbers in parentheses indicate change from 1981-82.

TABLE III

DOCTORAL DEGREES AWARDED EACH YEAR BY SCHOOL AND CITIZENSHIP

Each number is the total of the doctoral degrees awarded in September, February and June of the academic year indicated. The numbers in parentheses are the number of degrees awarded divided by the corresponding enrollment.

Academic Year		Arch.	Eng'g.	Hum. and Soc. Sci.	Sloan	Science	HST	Total
1973-74	Citizen	6 (.034)	93 (.088)	29 (.136)	5 (.021)	129 (.179)		262 (.109)
	Foreign	1 (.016)	49 (.099)	18 (.273)	6 (.052)	42 (.196)		116 (.122)
	Total	7	142	47	11	171		378
1974-75	Citizen	7 (.037)	104 (.095)	31 (.143)	10 (.040)	110 (.146)		262 (.105)
	Foreign	2 (.033)	56 (.107)	10 (.154)	8 (.080)	24 (.110)		100 (.103)
	Total	9	160	41	18	134		362
1975-76	Citizen	1 (.005)	83 (.073)	49 (.232)	12 (.055)	126 (.162)		271 (.106)
	Foreign	1 (.019)	67 (.114)	7 (.119)	2 (.017)	42 (.180)		119 (.113)
	Total	2	150	56	14	168		390
1976-77	Citizen	6 (.026)	79 (.068)	33 (.155)	2 (.007)	125 (.156)		245 (.090)
	Foreign	4 (.071)	64 (.106)	19 (.264)	1 (.010)	46 (.199)		134 (.126)
	Total	10	143	52	3	171		379
1977-78	Citizen	5 (.023)	111 (.096)	50 (.240)	8 (.029)	119 (.146)		293 (.110)
	Foreign	3 (.039)	66 (.103)	13 (.169)	15 (.139)	35 (.141)		132 (.115)
	Total	8	177	63	23	154		425
1978-79	Citizen	10 (.041)	80 (.066)	35 (.164)	10 (.035)	126 (.151)		261 (.093)
	Foreign	3 (.033)	64 (.101)	11 (.130)	9 (.088)	33 (.142)		120 (.105)
	Total	13	144	46	19	159		381
1979-80	Citizen	8 (.031)	96 (.074)	40 (.156)	5 (.017)	127 (.153)		276 (.094)
	Foreign	3 (.034)	66 (.096)	11 (.109)	3 (.029)	28 (.115)		111 (.091)
	Total	11	162	51	8	155		387
1980-81	Citizen	12 (.044)	88 (.065)	40 (.178)	7 (.022)	118 (.138)		265 (.088)
	Foreign	7 (.078)	75 (.103)	12 (.153)	2 (.020)	35 (.130)		131 (.104)
	Total	19	163	52	9	153		396
1981-82	Citizen	7 (.023)	94 (.066)	35 (.128)	4 (.012)	124 (.148)		264 (.083)
	Foreign	2 (.017)	75 (.104)	21 (.223)	6 (.050)	35 (.123)		139 (.103)
	Total	9	169	56	10	159		403
1982-83	Citizen	6 (.026)	93 (.070)	43 (.189)	11 (.031)	126 (.160)	1 (.100)	280 (.096)
	Foreign	4 (.027)	78 (.102)	14 (.150)	2 (.016)	52 (.184)	2 (.222)	152 (.107)
	Total	10	171	57	13	178	3	432

TABLE IV

A "SNAPSHOT" OF GRADUATE STUDENT SUPPORT "FULL AWARDS"

FALL TERM 1982

The following sources provided at least full tuition support for graduate students during the fall term 1982. Total regular graduate student enrollment, not including Non-Residents, was 4,349.

	Numbers of Students	Percent of Total Enrollment	Change from 81-82
FELLOWSHIPS AND TRAINEESHIPS AWARDED BY MIT			
NIH and NIMH Traineeships	113		+ 3
HEW Domestic Mining and Mineral Fuel Traineeships	0		- 7
HEW Graduate and Professional Opportunities Program Fellowships	0		- 6
M.I.T. Endowed and Other Fund Fellowships	175		-13
Industrial and Foundation Fellowships	183		+ 4
	471	11%	-19
FELLOWSHIPS AWARDED BY SPONSORS TO MIT STUDENTS			
NSF Graduate Fellowships	156		+ 9
NIMH Fellowships	3		+ 2
Hertz Fellowships	31		- 4
ONR Fellowships	5		+ 5
	195	4.5%	+12
STUDENT ASSISTANTSHIPS			
Research Assistants	1290		-165
Teaching Assistants	421		+ 30
Instructor G	6		- 2
	1717	39%	-137
SPONSORED STUDENTS			
Many students recieve support from employers and sponsors. The following reflect Student Accounts billings for tuition to employers and sponsors who presumably provide stipends to students by private arrangements:			
U.S. Army, Air Force, Coast Guard	45		+18
U.S. Navy and Related Programs	59		+ 6
Foreign Countries and International Programs	234		-19
Industry and Foundation (U.S.)	130		+ 1
	468	11%	+ 6
SUMMARY BY SOURCES - FULL AWARDS			
Federal Fellowships and Traineeships	277	6%	+ 4
Graduate Student Staff	1717	39%	-137
Industrial and Foundation Awards	214	5%	0
M.I.T. Endowed and Budgeted Funds	175	4%	- 13
Students Sponsored by External Sources	468	11%	+ 4
	2851	65.5%	-142

TABLE V

DISTRIBUTION OF FUNDING FOR GRADUATE STUDENT TUITION AND LIVING EXPENSES

FALL TERM 1982

Estimates of Required Funding

Tuition	$18,237,310
Stipend ($700/mo. for 4-1/2 months)	14,690,875
Total Estimated Required Funding	$32,928,185

Identified Support by Category

Research Assistantships	$ 9,460,161	(28.7%)
Teaching Assistantships and Inst. G.	3,789,916	(11.5%)
Federal Fellowships and Traineeships	2,003,518	(6.0%)
General and Endowed Support (departmentally controlled)	1,198,160	(3.6%)
General and Endowed Support (Graduate School Office controlled)	512,997	(1.5%)
Outside Sources Administered by departments	1,189,316	(3.6%)
Outside Sources Administered by Graduate School Office	638,824	(1.9%)
Outside Sources, Direct Billing to Sponsor by Institute, Tuition Only	1,552,357	(4.7%)
Total Identified Support	$20,345,249	(61.8%)
Loans	$ 3,777,559	(11.5%)
College Work-Study	$ 245,444	(.7%)

TABLE VI

TRENDS IN GRADUATE STUDENT SUPPORT

($000's)

Academic Year	Fellowships Traineeships Scholarships*	Staff Tuition Awards (TA & IG)	Staff Salaries (RA & TA)	Loans MIT Only	Loans Including Outside Agencies
1970-71	5,396 (.655)	1,182 (.143)	6,850 (.831)	483 (.059)	672 (.082)
1971-72	5,076 (.589)	1,294 (.150)	7,086 (.823)	696 (.080)	827 (.096)
1972-73	4,687 (.486)	1,432 (.150)	7,991 (.828)	754 (.078)	916 (.095)
1973-74	3,930 (.378)	1,453 (.140)	8,781 (.844)	852 (.082)	1,014 (.097)
1974-75	3,693 (.318)	1,738 (.150)	9,760 (.840)	1,075 (.093)	1,293 (.111)
1975-76	3,447 (.259)	1,878 (.141)	10,878 (.816)	1,141 (.086)	1,407 (.106)
1976-77	3,454 (.229)	2,065 (.137)	11,654 (.722)	1,419 (.094)	2,013 (.133)
1977-78	3,418 (.205)	1,978 (.118)	12,479 (.750)	1,391 (.084)	2,201 (.132)
1978-79	3,667 (.198)	2,355 (.127)	15,251 (.823)	962 (.052)	2,387 (.129)
1979-80	3,733 (.172)	3,079 (.142)	16,610 (.766)	976 (.045)	3,575 (.165)
1980-81	3,970 (.149)	2,821 (.106)	18,650 (.702)	434 (.016)	4,434 (.167)
1981-82	4,194 (.128)	3,362 (.102)	21,258 (.648)	662 (.020)	5,412 (.165)
1982-83	5,142 (.136)	4,044 (.107)	21,993 (.581)	1,078 (.028)	4,791 (.126)

*Administered by the Graduate School Office

To "normalize" these data, the total dollar values have been divided by the product (total regular graduate students registered Fall Term) (tuition for the 9-month academic year).

TABLE VII

WOMEN GRADUATE STUDENT ENROLLMENT

Comparison of Fall Term Enrollments - 1981 & 1982

	Number of Women		% of Women in Total Enrollment	
	1981	1982	1981	1982
School of Architecture & Planning				
Architecture IV	77	65	31%	27%
Urban Studies & Planning XI	80	87	45%	49%
	157	152	37%	37%
School of Engineering				
Aeronautics & Astronautics XVI	10	11	6%	6%
Chemical Engineering X	36	35	16%	17%
Civil Engineering I	31	25	12.5%	11%
Electrical Eng. & Computer Science VI, VI-A, VI-W	56	66	10%	11.6%
Materials Science III, III-B, III-W	40	36	17%	17%
Mechanical Engineering II, II-T, II-W	35	27	9%	7%
Nuclear Engineering XXII	13	12	8%	7%
Ocean Engineering XIII, XIII-A, XIII-B, XIII-W	9	6	5%	3%
	230	218	10.6%	10.4%
School of Humanities & Social Sciences				
Economics XIV	22	23	17%	18%
Linguistics/Philosophy XXIV	22	25	34%	43%
Political Science XVII	42	46	29%	29%
Psychology IX	10	9	32%	33%
	96	103	26%	28%
Sloan School of Management				
Management XV	81	108	21%	26%
XV-A (Fellows)	6	5	11%	9%
XV-B (Operations Research)	3	1	21%	17%
	90	114	20%	24%
School of Science				
Biology VII	32	39	25%	29%
VII-W	7	9	37%	47%
Chemistry V	47	50	22%	25%
Earth & Planetary Science XII	15	16	18%	19%
XII-W	14	13	36%	34%
Mathematics XVIII	24	22	20.5%	19%
Meteorology XIX	6	6	13%	14%
XIX-W	5	7	38%	44%
Nutrition & Food Science XX	67	68	42%	43%
Physics VIII	29	34	10%	11.5%
Interdisciplinary Science XXV	5	1	45.5%	50%
	251	265	22.3%	24%
HST	4	4	23.5%	21%
TOTALS	828	856	18.2%	19%

TABLE VIII

Women Graduate Student Enrollment

(% of total 1973-82)

	New			Continuing			Total		
Fall Term	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women
1973	105	1080	10%	213	2278	9%	318	3358	9%
1974	140	1061	13%	265	2407	11%	405	3468	12%
1975	175	1113	16%	312	2490	12.5%	487	3603	13.5%
1976	185	1220	15%	361	2554	14%	546	3774	14%
1977	192	1184	16%	367	2640	14%	559	3824	14.6%
1978	218	1259	17%	388	2685	14%	606	3944	15.4%
1979	193	1202	16%	491	2944	16.6%	684	4146	16.4%
1980	254	1308	19%	525	3076	17%	779	4384	18%
1981	243	1272	19%	585	3269	18%	828	4541	18%
1982	267	1306	20%	589	3183	19%	856	4489	19%

TABLE IX

COMPARISON OF ADMISSIONS STATISTICS FOR GRADUATE WOMEN AND GRADUATE MEN

Number of Applicants 1981/Number of Applicants 1982

Numbers in parentheses indicate the % change in number of applicants from 1981 to 1982

	Women	Men
School of Architecture & Planning	279/310 (+11%)	609/521 (-14%)
School of Engineering	306/293 (- 4%)	2830/3136 (+11%)
School of Humanities & Social Science	176/190 (+ 8%)	488/556 (+14%)
Sloan School of Management	451/414 (- 8%)	1661/1609 (- 3%)
School of Science	429/424 (- 1%)	1327/1343 (+ 1%)
TOTALS	1641/1631 (- 1%)	6915/7165 (+ 4%)

TABLE X

COMPARISON, IN NUMBERS, OF DEGREES AWARDED TO MEN AND WOMEN

1973-74 to 1982-83

	Master's			Doctor's			Engineer's			All		
	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women
1973-74	58	832	7%	34	378	9%	3	102	3%	92* 95	1210* 1312	7.6%* 7%
1974-75	80	856	9%	32	362	9%	0	107	0%	112* 112	1218* 1325	9%* 8.4%
1975-76	93	862	11%	33	390	8%	2	94	2%	126* 128	1252* 1346	10%* 9.5%
1976-77	145	971	15%	50	379	13.2%	2	91	2%	195* 197	1350* 1441	14.5%* 13.7%
1977-78	135	934	14%	48	425	11%	5	108	5%	183* 188	1359* 1467	13.4%* 12.7%
1978-79	145	968	15%	29	387	7%	2	65	3%	174* 176	1355* 1420	12.8%* 12.3%
1979-80	156	984	16%	47	386	12%	3	77	4%	203* 206	1370* 1447	14.8%* 14%
1980-81	184	1018	18%	65	396	16%	3	72	4%	249* 252	1414* 1486	17.6%* 16.9%
1981-82	214	1118	19%	49	403	12%	5	64	8%	263* 268	1521* 1585	17.3%* 16.9%
1982-83	198	1124	17.5%	71	432	16.5%	0	67	0%	269* 269	1556* 1623	17%* 16.5%

* without Engineer's degrees

TABLE XI

DEGREES AWARDED TO WOMEN BY SCHOOL

(Sept., Feb., June)

	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
Architecture & Planning												
Master's*	12	23	13	23	23	34	23	33	41	48	51	48
Doctor's	1	1	1	2	0	2	4	3	5	6	2	6
Engineering												
Master's	12	14	22	16	21	28	42	50	51	62	84	72
Doctor's	2	0	3	3	3	8	4	4	7	14	10	14
Humanities & Social Sciences												
Master's	2	0	3	4	3	5	4	3	3	3	5	5
Doctor's	5	10	10	8	10	10	12	4	12	14	10	14
Sloan												
Master's	10	3	11	21	26	46	40	45	34	49	47	47
Doctor's	0	0	0	0	0	0	2	0	1	1	0	3
Science												
Master's	6	11	9	16	19	32	25	14	27	21	25	25
Doctor's	23	13	20	19	19	28	23	18	20	26	23	29
Operations Research (XV-B)												
Master's	0	0	0	0	1	0	1	0	0	1	2	1
Doctor's	0	0	0	0	0	0	1	0	0	2	0	1
WHOI												
Doctor's	0	0	0	0	1(VII-W)	1(VII-W) 1(XII-W)	1(VII-W) 1(XII-W)	0	1(VII-W) 1(XII-W)	2(XII-W)	3(XII-W) 1(XIX-W)	2(XII-W) 1(XIX-W)
HST												
Doctor's	-	-	-	-	-	-	-	-	-	-	-	1
TOTALS												
Master's	42	51	58	80	93	145	135	145	156	184	214	198
Doctor's	31	24	34	32	33	50	48	29	47	65	49	71

*M. Arch., M.C.P., S.M.

TABLE XII

Trends in Minority Graduate Enrollment at MIT*

Minority Graduate Enrollment

SCHOOL	1974	1975	1976	1977	1978	1979	1980	1981	1982
Architecture & Planning	41	50	59	44	46	45	57	41	31
Engineering	38	38	44	40	44	47	58	55	55
Management	10	9	17	20	13	9	16	10	12
Humanities & Social Sciences	34	30	27	21	16	9	15	9	12
Science	28	28	31	32	28	34	25	25	28
Total Minority Enrollment	151	155	178	157	147	144	171	140	139+
Total Graduate Enrollment*	3,468	3,603	3,744	3,824	3,944	4,146	4,327	4,435	4,349

Black Graduate Enrollment

SCHOOL	1974	1975	1976	1977	1978	1979	1980	1981	1982
Architecture & Planning	34	39	45	34	32	34	40	30	23
Engineering	26	25	25	25	33	33	37	35	34
Management	10	8	13	17	12	8	16	10	12
Humanities & Social Sciences	31	26	23	17	14	9	12	5	5
Science	22	21	24	21	20	20	16	17	18
Total Black Enrollment	123	119	130	114	111	104	121	97	93+

+ Totals include one black graduate student registered in the HST Program.

* Does not include Special or Non-Resident Graduate Student Enrollment.

TABLE XIII

TOTAL AND MINORITY REGULAR* GRADUATE ENROLLMENT

Fall 1982

	BA	PR	MA	AI	Total Minority Graduate Students	Total Graduate Students	% of Total
ARCHITECTURE & PLANNING							
Architecture (IV)	10 (4)	0	3	0	13 (4)	231	5.6
Urban Studies & Planning (XI)	13 (5)	1	3 (3)	1 (1)	18 (9)	144	12.5
	23 (9)	1	6 (3)	1 (1)	31 (13)	375	8.3
ENGINEERING							
Aeronautics & Astronautics (XVI)	2 (1)	2	1	0	5 (1)	188	2.7
Chemical Engineering (X)	7 (3)	0	1	0	8 (3)	207	3.9
Civil Engineering (I,I-W)	0	1	0	0	1	214	0.5
Electrical Engineering & Computer Science (VI)	17 (4)	4 (2)	2 (1)	0	23 (7)	568	4.0
Materials Science & Engineering (III)	1	1	0	0	2 (1)	206	0.9
Mechanical Engineering (II, II-T, II-W)	6 (2)	4 (2)	3 (1)	0	13 (5)	368	3.5
Nuclear Engineering (XXII)	1	0	1 (1)	0	2 (1)	164	1.2
Ocean Engineering (XIII, XIII-W, XIII-A, XIII-B)	0	1 (1)	0	0	1 (1)	175	0.6
	34 (10)	13 (5)	8 (3)	0	55 (19)	2090	2.6
SLOAN SCHOOL OF MANAGEMENT (XV, XV-A, XV-B)	12 (3)	0	0	0	12 (3)	475	2.5
HUMANITIES & SOCIAL SCIENCE							
Economics (XIV)	2 (1)	1	1 (1)	2 (1)	6 (3)	127	4.7
Philosophy & Linguistics (XXIV)	0	0	0	0	0	44	0
Political Science (XVII)	3 (1)	0	2	1 (1)	6 (2)	122	4.9
Psychology (IX)	0	0	0	0	0	27	0
	5 (2)	1	3 (1)	3 (2)	12 (5)	320	3.8
SCIENCE							
Biology (VII, VII-W)	3 (2)	2	1	0	6 (2)	153	3.9
Chemistry (V)	4	1	1	0	6	192	3.1
Earth & Planetary Sciences (XII, XII-W)	0	0	0	0	0	120	0
Interdisciplinary (XXV)	0	0	0	0	0	2	0
Mathematics (XVIII)	1	0	2 (1)	0	3 (1)	100	3.0
Meteorology (XIX, XIX-W)	0	0	0	0	0	57	0
Nutrition & Food Science (XX)	2 (2)	0	0	0	2 (2)	154	1.3
Physics (VIII)	8 (2)	2	1	0	11 (2)	292	3.8
	18 (6)	5	5 (1)	0	28 (7)	1070	2.6
HST	1	0	0	0	1	19	5.2
TOTALS	93 (30)	20 (6)	22 (8)	4 (3)	139 (47)	4349	3.2

( ) = New Students

BA = Black Americans, PR = Puerto Ricans, MA = Mexican Americans, AI - American Indians

* Does not include 6 minority non-resident students of 140 total non-resident students

TABLE XIV

Minority Applicants Admitted and Enrolled

1981-82 vs. 1982-83

	1981-82			1982-83		
	Recd.	Admitted	Enrolled	Recd.	Admitted	Enrolled
ARCHITECTURE & PLANNING						
Architecture (IV)	14	6	3	13	5	4
Urban Studies & Planning (XI)	35	13	5	49	19	9
	49	19	8	62	24	13
ENGINEERING						
Aeronautics & Astronautics (XVI)	6	3	3	1	1	1
Chemical Engineering (X)	9	5	3	8	3	3
Civil Engineering (I, I-W)	6	3	0	3	2	0
Electrical Engineering & Computer Science (VI)	18	11	7	34	13	7
Materials Science & Engineering (III)	0	0	0	3	2	1
Mechanical Engineering (II, II-T, II-W)	8	6	3	19	13	5
Nuclear Engineering (XXII)	0	0	0	1	1	1
Ocean Engineering (XIII, XIII-W, XIII-A, XIII-B)	0	0	0	1	1	1
	47	28	16	70	36	19
SLOAN SCHOOL OF MANAGEMENT (XV, XV-A, XV-B)	63	14	5	63	17	3
HUMANITIES & SOCIAL SCIENCES						
Economics (XIV)	6	2	0	11	4	3
Linguistics & Philosophy (XXIV)	1	0	0	2	1	0
Political Science (XVII)	4	3	2	7	4	2
Psychology (IX)	2	0	0	2	0	0
	13	5	2	22	9	5
SCIENCE						
Biology (VII, VII-W)	2	1	1	2	2	2
Chemistry (V)	5	2	1	8	3	0
Earth & Planetary Sciences (XII, XII-W)	0	0	0	1	0	0
Interdisciplinary (XXV)*	0	0	0	0	0	0
Mathematics (XVIII)	0	0	0	1	1	1
Meteorology (XIX, XIX-W)	0	0	0	1	0	0
Nutrition & Food Science (XX)	2	0	0	3	3	2
Physics (VIII)	10	1	1	10	6	2
HST	19	1	0	21	2	0
	38	5	3	47	17	7
TOTALS	210	71	34	264	103	47

*Course XXV is no longer admitting students.

TABLE XV

Minority Graduate Degree Recipients

1982-83

(September, February, June Degree Lists)

	Black	Hispanic*	NA	Total
Master's	29	12	0	41
Engineer's	1	1	0	2
Doctor's	7	1	0	8
Total	37	14	0	51

	Master's			Engineer's			Doctor's			
Degree List	B	HS*	NA	B	HS*	NA	B	HS*	NA	Total
September	4	2	0	0	0	0	2	0	0	8
February	4	5	0	1	0	0	3	1	0	14
June	21	5	0	0	1	0	2	0	0	29
Total	29	12	0	1	1	0	7	1	0	51

B = Black American

*HS = Hispanic (Mexican American and Puerto Rican)

NA = Native American

Medical Department

This year - a full twelve months in our new building - saw many "firsts". It was also, unfortunately, marked by some significant "lasts". A solid support for the Department over many years and a great friend for all who work in it, Vice President Kenneth R. Wadleigh announced his departure from the MIT Administration to resume his professorial duties in the Department of Mechanical Engineering. We note this, for us, apocalyptic metamorphosis with a keen sense of bereavement.

May 31, 1983 saw the severance of several ties connecting the Department with the MIT Information Processing Service. What had been, a decade ago, on the "cutting edge" of information systems in support of a medical enterprise has, simply, been outgrown. Disconnecting from the old system is a step necessary to our embarking on the development of modern, useful and cost-effective information handling systems - an effort now in process.

The necessity for reducing the Department's expenditures - reflecting the requirement weighing on the Institute - cannot be met in a people-rich Department like ours without reducing the number of people. For the first time in memory, it has been necessary to lay-off some employees in addition to the voluntary departures noted below. Indeed, dealing with the effects of the financial retrenchment on those who remain, as well as those who must leave the Institute, has become an important activity for several services in this Department.

A happier "last" - the end of the Consolidated Complaint List which recorded problems in the new facility - occurred with the remedy of many of the deficiencies and the establishment of the Facilities Group which addresses problems which now arise at a tolerably low volume.

But there have been firsts - and positive accomplishments, too. The first survey by the Joint Commission on Accreditation of Hospitals (JCAH) of the MIT Medical Department as hospital occurred on April 29, 1983. Preparation for the survey involved dedicated efforts by many people over many months. Whether or not we achieve accreditation, the benefits of this preparatory effort will be palpable. They include focusing on some "identity crisis" problems in the organizational structure of the Department and its relationship to the several entities within MIT which have some jurisdiction over it. Since identity crises often characterize adolescence, perhaps we may anticipate the advent of some maturity in the near future.

Codification of policies and procedures for all administrative services was also accomplished in preparation for the survey.

Several program activities grew substantially this year:

Utilization of the newly established X-ray capabilities made possible in our new building increased linearly since June, 1982. We now average more than 50 studies per month (Upper G.I. Series, Barium Enemas, Gallbladder, I-V Pyelograms) to the benefit of our patients (convenience and continuity of care) and the Institute (reduced costs).

The Pharmacy has blossomed and established itself as an important participant in the Department's provision of excellent health care. Use of the pharmacy by our patients continues to grow; revenues have approached the break-even point much earlier than anticipated. Patients are enthusiastic about the quality of the services provided as well as the reasonable cost of the medications available. David Bailey, our pharmacist, and his associate Georgene Bloomfield, are hard-working and very effective.

Several new procedures have been instituted in Medical Records, including a coding system which, for the first time, integrates all of the satellite records with the main medical record system. A new patient-registration procedure helps assure the accuracy and currency of the information necessary for the management of patient records. Policies which assure the privacy and confidentiality of patient records have been strengthened and rearticulated.

The quality of the meals served in the Infirmary has increased substantially, under the influence of Judy Klayman and Judy Melegrano.

Our participation as a training site in the Primary Care Internal Medicine Program at the Mount Auburn Hospital (Harvard Medical School) encompassed two residents this year - Dr. Gail Clinton and Dr. John Kryder. They will continue to work in the Department this coming year as well.

A comprehensive program of prenatal educational classes was introduced in December, 1982 by Connie Bean and Karen Halvorson.

Under the leadership of Katherine Mulligan, RNPC, 18 programs of continuing education for nurses were presented, many of which were certified by the Massachusetts Nurses Association.

The IAP activities, under the direction of Dr. Bruce Biller, and Connie Bean and Brenda Lindemann, health educators, reached a level of 60 programs, with 69 sessions and 1,883 people attending - all new highs.

A new offering which addresses a substantial hazard for very young patients — a car-seat loan program for infants — was established in February. All of the available seats are either reserved or in use; more have been ordered.

Staff Changes

The number of changes continues to be small. Some must be particularly noted:

Mrs. Pauline Jones, who has been our Director of Nurses, Disaster Plan Expert, Outside Clinical Service Coordinator and the embodiment for many Health Plan members of MIT as alma mater has decided to heed the seductive whispers of the golf course and work on her handicap. We will benefit from her continued presence for but a few more months.

Dr. Edward S. Rendall has, similarly, found the attractions of the life of a country squire in Maine to be irresistible. His patients, colleagues and friends will miss him sorely.

Marie Jeon left so quietly - at her insistence - that many did not know of the departure of this extraordinarily effective, hard-working and loyal member of the Department.

On a happier note, Dick Chamberlin has continued to demonstrate his effectiveness and leadership in the Environmental Medical Service. His promotion to Associate Director of that Service recognizes those splendid capabilities.

APPOINTMENTS

Georgene Bloomfield
Pharmacist

Joan L. Bolker
Postdoctoral Fellow
Psychiatry

Susan Carson
Inpatient Nurse

Laurent C. Delli-Bovi
Obstetrician/Gynecologist

Joan A. Flewelling
Inpatient Nurse

Robert F. Golinveaux
Pharmacist

Karen Halvorson
Nurse Practitioner

Sharon Jackson
Administrator, Dental Service

Carol Kaminsky-Ritter
Physical Therapist

Timothy Kaminsky
Physical Therapist

Judith Melagrano
Supervisor, Nutritional Care

Mary-Janet Rombola
Dental Hygienist

Gay Torresyap
Dental Hygienist

RESIGNATIONS

Deborah Greenman
Postdoctoral Fellow
Psychiatry

Joy Ann Kay
Inpatient Nurse

RESIGNATIONS (cont.)

Marie T. Jeon
Senior Manager
Member Services & Claims
MIT Health Plan

Pauline R. Jones
Special Assistant to
Medical Director

Edward S. Rendall
Physician

Mary-Janet Rombola
Dental Hygienist

CHANGES

Richard Chamberlin
Promotion: Associate Director
of Environmental Medical Service

Deborah Dacus
Additional Title: Administrator;
Director of Nursing Service

Level of Activity

There was essentially no change in the number of visits to the Department compared with a year ago (119,164 vs. 119,043). Within this constant perimeter, however, there were interesting shifts and changes:

Student visits declined by 1,465 (4%) while Health Plan visits increased by 2,282 (4.8%). Students made fewer visits to Internal Medicine and "Nursing" (non-physician providers) service, but increased their utilization of gynecology and orthopedics.

Utilization of the off-hours service by Health Plan members climbed steeply by 710 visits (46%) - probably reflecting the convenience of access and parking in our new location as well as the increased sophistication of Health Plan members in proper utilization of the Health Plan resources.

Psychiatric and Dental services also experienced sharply increased utilization.

The last report from this Department noted a decline in visits to non-physician providers by students and others. Concern as to possible causes for this phenomenon were expressed. Some of the factors which may be important have been identified:

There has been a change in the Institute-wide tuberculin-testing program. Skin tests are no longer performed every three years. These formerly were done by nursing service providers.

We now have a pharmacy. Free "starter" quantities of prescribed medications are no longer dispensed in pre-packaged doses by non-physician providers.

The mode of accommodating walk-in patients favors physician appointments over those for non-physicians. The addition of two physicians the year before last made more physician appointments available.

Although we continue to be concerned that our new location, remote from many student living groups, may impose a barrier between us and these patients, utilization by students continues to be quite full.

VISITS TO DEPARTMENT

	'81/'82	'82/'83	Change
Total	119,042	119,164	+/-
Internal Medicine:	25,605	25,376	+/-
Students:	9,031	8,078	-10.5%
"Nursing":	19,433	17,087	-12 %
Students:	8,426	7,807	- 7 %
Orthopedics:	5,520	6,014	+ 9 %
Students:	2,089	2,343	+12 %

VISITS TO DEPARTMENT (cont.)

	'81/'82	'82/'83	Change
OB/GYN:	7,753	7,748	+/-
Students:	1,602	1,690	+ 5.5%
Total Students:	34,557	33,092	- 4 %
Total HP:	47,838	50,120	+ 4.8%
Visits/Student /Year:	_____	3.68	
Visits/HP/Year:	_____	6.17	
Off-Hours Service:	5,611	5,882	+ 4.8%
Students:	2,694	2,752	+/-
HP:	1,534	2,244	+46 %
Psychiatry:	7,271	8,043	+10.6%
Students:	2,131	2,574	+20.8%
HP:	3,781	4,361	+15.3%
Dental:	8,195	9,802	+19.6%
HP:	2,480	3,558	+43.5%

Environmental Medical Service

There has been a determined effort this year to eliminate duplication of function, to combine activities where possible and to minimize the time required for routine tasks. However, Richard Chamberlin points out, there has been a continuing drain on available resources in allaying unfounded fears resulting from misinformation, over-reaction to incidents, and even unwillingness to accept factual data. A continuing education program is needed to provide perspective.

EMS staff members continue to serve as advisors to government agencies setting guidelines or developing regulations for environmental issues. The added needs which may result where these guidelines and regulations become operative cannot be realistically estimated at this time. Of great importance, nonetheless, in any increased level of EMS activity will be the preservation of the "friendly advisor" role for this service - without which its effectiveness is at great risk.

It is a pleasure to report that MIT's Nuclear Regulatory Commission by-product materials license was renewed in May — after much effort in revising the application (since 1979), responding to inquiries and effecting changes to conform with revisions in NRC rules and regulations.

Social Work Service

Ronald Fleming, Chief of this Service, offers this capsule:

"This year was characterized by two major influences, one internal to the Medical Department, the other within the M.I.T. community. The JCAH accreditation effort has created a positive effect on the Social Work Service by clarifying expectations about clinical and administrative performance, both within the Service and relative to the Department as a whole. The process also served to remind us of the nature of 'outside' standards and to reassure us that our performance not only meets, but often exceeds such standards.

"M.I.T.'s financial retrenchment has been the other major influence upon the Social Work Service. While thus far the effect has not been on the Service directly, we are seeing growing evidence of the effects of the financial hardships on employees, both those who remain employed and certainly on those laid off due to lack of funds. Among those laid off we have seen and responded to the trauma of the loss of employment. Remaining employees, however, have shown the effects in morale problems, tension, and insecurity. The Social Work Service has been involved in direct counseling of employees as well as in supervisory seminars developed by Personnel to acquaint supervisors with the issues and complexities of the layoff process."

The Institute Personal Assistance Program continues to expand. The Institute-wide ad hoc committee which generated this major program has been replaced by a Presidentially appointed committee representing many constituencies at M.I.T. It will provide support and focus for Mr. Fleming and his colleagues.

The demand for clinical services continues high — probably close to saturation-point for a service of this size. During busy months, indeed (February - May), the wait between first call and first visit may reach four to six days — longer than is comfortable for many.

Psychiatry Service

The sharp increase in utilization by students has already been noted. A 50% increase in freshman and post-doctoral students probably reflects points of stress in our community. Of interest is the observation that only 12% of patients using this service come from the international community, representing less than half of what might be expected on the basis of number in the community.

The M.I.T. Health Plan

Laurence Bishoff offers this summary:

"There are 8,023 members of the M.I.T. Health Plan as of this report. Almost 6,900 of these people are M.I.T. affiliates and their families; just over 1,000 members are enrolled through the Draper Laboratory; a small number of staff at the Harvard Community Health Plan continue as members. This year enrollment was inaugurated for employees of the Whitehead Institute for Biological Research. The M.I.T. Health Plan has once again been the most popular health benefits choice for new employees at M.I.T., even in the face of increasing competition from other health care programs offered here.

"Emphasis on control of hospital utilization has had strong effects on the number of hospital days this year. The Plan used only 348 days per 1,000 members in acute care hospitals — almost 20% less than the average for plans of comparable size or age throughout the United States. This achievement is especially impressive in light of the high rate of hospital admissions for mental illness. Fully one-third the total hospital use was for psychiatric admissions. Credit for control of medical and surgical admissions must be given to the medical staff and the mechanisms created to monitor stays in the hospital.

"Full use of our new departmental facilities for x-ray testing, orthopedic services, laboratory services, and the introduction of on-site examination of surgical pathology specimens contributed strongly to controlling the use of hospital outpatient services. As a result, the Plan will contribute more than its expected measure to the Institute's overhead funding for employee benefit services.

"A hallmark of the M.I.T. Health Plan has been personal, responsive service by the enrollment and claims staff. This year, Marie Jeon, Senior Manager for Claims and Member Services, has retired. She has been a stalwart leader of our staff since the Plan's inception who has always given exemplary service to members. The staff will feel the loss of her presence, personally and professionally. It will be a challenge to maintain the high standards of service she set."

We start the new year with a new relationship. This Department now reports administratively to Vice President Constantine B. Simonides. The support of the Department by the M.I.T. administration has always been rock-solid. We are confident that this firm foundation will continue to uphold us through him.

MELVIN H. RODMAN, M.D.

Division of Comparative Medicine

The past year, on both the state and national levels, has been marked by increasing pressures from the animal-rights activists to restrict, legislate, and in some cases attempt to abolish use of animals in biomedical research. Though the Institute is AAALAC (American Association for Accreditation of Laboratory Animal Care) accredited and fully in compliance with NIH standards for the care and use of laboratory animals, the Institute Animal Care Committee, recognizing the increasing sensitivity of these emotional issues, has resolved to move expeditiously in formulating institutional policies on protocol review of animal experimentation patterned after the Committee on the Use of Humans as Experimental Subjects. These policies, when fully implemented, would not only benefit the Institute, but might also assist those who are attempting to formulate more responsible legislation regarding animal use in biomedical research.

The Division of Comparative Medicine has continued to upgrade and assess animal resource programs under its direction. The new Whitaker animal resource complex (16,000 GSF) which includes 1,200 GSF of surgical suites is now fully operational. In addition to housing animals utilized by Whitaker's faculty, it also accommodates animals for the NSF neuro-edocrinology group (formerly housed in Building 37), as well as several faculty members of Psychology. The substandard E10 animal care facility now houses animals utilized by only two remaining faculty members. The resolution of the fate of this facility must be addressed within the next year.

During the past year, the Division purchased and produced approximately 100,000 animals. It was also responsible for the health monitoring of an additional estimated 300,000 animals on an annual basis. Because of the economic downturn, the daily census of animals at MIT has been stationary. However, with a greater interest by the faculty in biomedical engineering, larger species (and hence requiring more space) are being used with increased frequency.

The Division's Research Animal Diagnostic Laboratory (RADL) has now been in operation for seven years and continues to be responsible for diagnostic services for more than 80,000 animals a day, including those housed at MIT as well as at many research institutions throughout the Boston area. The funds for operating this laboratory are generated from the National Institutes of Health and from services provided to several outside research institutions in the Boston area.

The Division remains active in teaching undergraduates, graduates, and summer veterinary students. In addition, we have initiated a postdoctoral training program for graduate veterinarians in Comparative Medicine and currently have two postdoctoral fellows.

Independent and collaborative research continues unabated. The Division has received international recognition for its investigative work in Campylobacteriosis a "new" disease in man and laboratory animals. The Division's faculty and staff during the year have published 14 articles and 10 abstracts, in addition to presenting nine papers at national meetings.

JAMES G. FOX

REGISTRAR

All statistics on Registration and staff in the following tables are given as of the fifth week of the Fall Term, except: 1943-44 as of August 2, 1943; 1944-45 as of November 27, 1944; and 1945-46 as of July 30, 1945.

TABLE I STUDENT REGISTRATION SINCE THE FOUNDING OF THE INSTITUTE*

YEAR	NUMBER OF STUDENTS	YEAR	NUMBER OF STUDENTS	YEAR	NUMBER OF STUDENTS
1865-66	72	1906-07	1,397	1947-48	5,662
1866-67	137	1907-08	1,415	1948-49	5,433
1867-68	167	1908-09	1,461	1949-50	5,458
1868-69	172	1909-10	1,479	1950-51	5,171
1869-70	206	1910-11	1,506	1951-52	4,874
1870-71	224	1911-12	1,559	1952-53	5,074
1871-72	261	1912-13	1,611	1953-54	5,183
1872-73	348	1913-14	1,685	1954-55	5,348
1873-74	276	1914-15	1,816	1955-56	5,648
1874-75	248	1915-16	1,900	1956-57	6,000
1875-76	255	1916-17	1,957	1957-58	6,179
1876-77	215	1917-18	1,698	1958-59	6,259
1877-78	194	1918-19	1,819	1959-60	6,270
1878-79	188	1919-20	3,078	1960-61	6,289
1879-80	203	1920-21	3,436	1961-62	6,454
1880-81	253	1921-22	3,505	1962-63	6,695
1881-82	302	1922-23	3,180	1963-64	6,925
1882-83	368	1923-24	2,949	1964-65	7,151
1883-84	443	1924-25	2,938	1965-66	7,408
1884-85	579	1925-26	2,813	1966-67	7,567
1885-86	609	1926-27	2,671	1967-68	7,730
1886-87	637	1927-28	2,712	1968-69	7,764
1887-88	720	1928-29	2,868	1969-70	8,024
1888-89	827	1929-30	3,066	1970-71	7,799
1889-90	909	1930-31	3,209	1971-72	7,717
1890-91	937	1931-32	3,188	1972-73	7,850
1891-92	1,011	1932-33	2,831	1973-74	7,888
1892-93	1,060	1933-34	2,606	1974-75	8,050
1893-94	1,157	1934-35	2,507	1975-76	8,482
1894-95	1,183	1935-36	2,540	1976-77	8,597
1895-96	1,187	1936-37	2,793	1977-78	8,712
1896-97	1,198	1937-38	2,966	1978-79	8,881
1897-98	1,198	1938-39	3,093	1979-80	9,053
1898-99	1,171	1939-40	3,100	1980-81	9,365
1899-00	1,178	1940-41	3,138	1981-82	9,510
1900-01	1,277	1941-42	3,055	1982-83	9,475
1901-02	1,415	1942-43	3,048		
1902-03	1,608	1943-44	1,579		
1903-04	1,528	1944-45	1,198		
1904-05	1,561	1945-46	1,538		
1905-06	1,466	1946-47	5,172		

*From 1943 to 1946 Army and Navy students are omitted (see Table III-B in reports for 1943 to 1946)

TABLE I-A STUDENT REGISTRATION IN THE SUMMER SESSION SINCE 1948

YEAR	*IN REGULAR SUBJECTS	+IN OTHER SUBJECTS	YEAR	*IN REGULAR SUBJECTS	+IN OTHER SUBJECTS
1948	2,146	-	1968	2,490	1,739
1949	1,875	171	1969	2,241	1,719
1950	1,852	259	1970	2,185	1,666
1951	1,861	813	1971	2,197	1,109
1952	1,689	832	1972	2,121	1,235
1953	1,672	1,289	1973	2,205	1,367
1954	1,675	1,398	1974	2,153	1,701
1955	1,619	1,653	1975	2,238	1,430
1956	1,553	2,497	1976	2,317	1,614
1957	1,548	1,757	1977	2,321	1,724
1958	1,650	1,752	1978	2,344	1,611
1959	1,635	1,510	1979	2,610	1,748
1960	1,600	1,696	1980	2,627	1,720
1961	1,668	1,412	1981	2,685	1,722
1962	1,748	1,763	1982	2,707	1,329
1963	1,808	1,397			
1964	1,882	1,492			
1965	2,090	1,568			
1966	2,054	1,787			
1967	2,218	1,829			

*Students attending regular subjects from M.I.T. curricula.
+Students attending professional subjects which are not a part of M.I.T. curricula and in general carry no academic credit.

TABLE II ACADEMIC STAFF COUNT

	Professors*	Administration also Professors*	Institute Professors Emerti-Part Time*	Adjunct Professors*	Associate Professors*	Assistant Professors*	Sr. Lecturers and Professors Emerti*	Sr. Lecturers	Lecturers	Sr. Research Scientists	Instructors	Technical Instructors	Sr. Research Associates	Postdoctoral Associates	Research Assistants	Teaching Assistants	Instructor Grad	Total	Visiting Professors	Others[1]
Institute Professors	12	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	1	-
School of ARCHITECTURE AND PLANNING																				2
Architecture	14	2	-	5	14	9	-	-	10	-	7	8	-	-	14	33	1	117	2	12
Urban Studies and Planning	12	-	-	1	10	4	-	-	3	-	2	-	-	-	13	-	11	56	4	21
Total	26	2	-	6	24	13	-	-	13	-	9	8	-	-	27	33	12	173	6	35
SCHOOL OF ENGINEERING	1	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Aeronautics and Astronautics	26	2	-	2	4	8	4	6	14	-	-	3	-	1	112	2	-	184	1	14
Chemical Engineering	15	2	-	2	9	5	-	1	2	-	2	1	-	1	78	39	1	158	1	17
Civil Engineering	18	2	-	-	18	7	1	4	2	-	-	-	-	2	78	25	4	161	4	16
Electrical Engineering and Computer Science	51	13	-	3	25	19	3	3	9	3	-	1	1	2	207	115	1	456	-	26
Materials Science and Engineering	21	1	-	1	8	5	1	-	1	-	-	2	1	4	122	21	1	189	-	39
Mechanical Engineering	28	4	-	-	16	14	1	7	18	1	-	6	1	3	179	17	1	296	2	29
Nuclear Engineering	14	2	-	1	4	4	1	-	-	-	-	-	1	-	65	17	2	111	2	12
Ocean Engineering	10	1	-	1	7	4	1	-	-	-	-	-	1	-	42	10	-	77	4	9
Total	184	29	-	10	94	66	12	21	46	4	2	13	5	13	883	246	10	1,638	14	162
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE	1	-	-	-	-	-	-	1	6	-	-	3	-	-	-	-	-	11	1	2
Economics	18	1	-	-	3	5	-	-	-	-	1	-	-	-	12	32	-	72	3	6
Humanities	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Anthropology/Archaeology	1	-	-	-	5	2	-	-	1	-	-	-	-	-	-	-	-	9	-	-
Foreign Languages and Linguistics	2	-	-	-	6	8	-	1	16	-	-	-	-	-	-	-	-	33	-	2
History	8	-	-	-	4	3	-	-	-	-	1	-	-	-	-	-	-	16	-	-
Literature	5	-	-	-	4	6	-	1	2	-	1	-	-	-	-	-	-	19	1	-
Music	2	-	-	-	6	2	-	1	6	-	1	1	-	-	-	-	-	19	-	11
Writing Program	-	-	-	-	4	6	-	1	9	-	-	1	-	-	-	-	-	21	1	-
Linguistics and Philosophy	14	1	-	-	3	3	-	-	-	-	1	-	-	-	21	8	1	52	1	14
Political Science	15	2	-	-	3	8	-	1	1	-	-	-	-	-	12	10	-	52	-	8
Psychology	9	1	-	-	4	2	-	-	1	-	-	3	-	4	3	-	-	27	-	39
Science, Technology and Society	5	1	-	-	6	-	-	-	1	1	-	-	-	-	-	-	-	14	3	7
Total	80	8	-	-	48	45	-	6	43	1	5	8	-	4	48	50	1	347	10	89
SLOAN SCHOOL OF MANAGEMENT																				
Management	35	2	-	4	14	22	1	6	5	-	-	1	-	2	35	46	-	173	5	30
SCHOOL OF SCIENCE																				2
Biology	27	2	-	-	7	4	1	-	1	-	3	-	1	54	25	-	-	125	1	83
Chemistry	21	2	-	-	1	5	3	-	1	-	-	2	-	50	102	47	-	234	2	49
Earth and Planetary Sciences	14	1	-	-	7	4	-	-	-	1	1	-	-	10	68	13	-	119	3	26
Mathematics	37	1	-	-	3	13	-	1	2	-	24	-	-	-	5	59	-	145	4	31
Meteorology and Physical Oceanography	6	1	-	-	1	4	-	-	-	-	-	-	-	3	41	2	-	58	3	11
Nutrition and Food Science	10	2	-	1	10	5	1	4	12	1	-	-	-	25	72	16	-	159	3	107
Physics	60	6	-	-	17	7	1	-	-	11	-	5	-	10	204	37	-	358	4	20
Total	175	15	-	1	46	42	6	5	16	13	28	7	1	152	517	174	-	1,198	20	329

Administration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
Aerospace Studies	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	8	1	-	
Artificial Intelligence Laboratory	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	11	
Athletic	-	1	-	-	7	5	-	-	2	-	12	-	-	-	-	-	-	27	1	22	
Center for Advanced Engineering Study	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
Center for Advanced Visual Studies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	
Center for Cancer Research	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	46	
Center for Cognitive Science	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
Center For International Studies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	
Center for Materials Science and Engineering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	
Center for Policy Alternatives	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	3	-	5	
Center for Space Research	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	1	
Center for Transportation Studies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
Clinical Research Center	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	
Division for Comparative Medicine	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	8	
Division for Study and Research in Education	1	1	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	6	1	1	
Energy Laboratory	-	-	-	-	-	-	-	-	-	2	-	-	-	4	-	-	-	6	-	29	
Francis Bitter National Magnet Laboratory	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	29	
Harvard-MIT Health Sciences and Technology	-	1	-	-	-	1	-	-	2	1	-	-	-	4	-	-	-	9	1	12	
Laboratory of Architecture and Planning	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	8	
Laboratory for Computer Science	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	2	-	16	
Laboratory for Information and Decision Systems	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	6	
Laboratory for Nuclear Science	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	
Libraries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74	
Materials Processing Center	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	6	
Medical	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	148	
Military Science	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	6	1	2	
Naval Science	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	8	1	-	
Nuclear Reactor Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	
Office of the Provost	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	
Operations Research Center	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
Plasma Fusion Center	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	4	-	13	
Research Laboratory of Electronics	-	-	-	-	-	-	-	-	-	1	-	-	-	9	-	-	-	10	-	69	
Sea Grant Program	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	
Spectroscopy Laboratory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	
Student Activities	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	8	-	-	
Whitaker College of Health Science, Technology and Management	1	-	-	-	-	1	-	-	-	-	-	-	-	-	5	-	-	7	-	7	
Total	3	5	-	-	10	8	-	-	4	13	12	30	3	25	5	-	-	118	6	626	
GRAND TOTAL	515[2]	62[2]	1[2]	21[2]	236[2]	196[2]	19[2]	38[2]	127[2]	31	56[2]	67[2]	9	196	1,515	549[2]	23[2]	3,661	62[3,4]	1,271[3]	
Faculty Ex-Officiis																		39			
																		3,700			

*Total Faculty 1,089

[1]Includes Administrative Officers, affiliated Artists, Coaches and Trainers, Guests, Honorary Lecturers, Institute Organist, Visiting Lecturers and Senior Lecturer, Librarians, Medical Doctors, Postdoctoral and Research Fellows, Postdoctoral Trainees, Research Affiliates, Senior Research Engineer,

[2]Supply Sergeant, Visiting Economists, Visiting Engineers, Visiting Scholars, Visiting Scientists.

[3]Total Teaching Staff 1,910

[4]Not included in preceding total

[4]Visiting Professors include 31 Professors, 22 Associate Professors, 9 Assistant Professors

TABLE III CLASSIFICATION OF STUDENTS SINCE 1980

COURSE NAME	1980-81 2	3	4	G	Non Res.[1]	Total	1981-82 2	3	4	G	Non Res.[1]	Total
SCHOOL OF ARCHITECTURE AND PLANNING												
Architecture, IV	16	31	33	204	4	288	29	21	35	250	6	341
Architecture, IV-B	-	1	-	-	-	1	-	-	-	1	-	1
Urban Studies and Planning, XI	3	2	10	190	24	229	1	5	4	173	32	215
Total	19	34	43	394	28	518	30	26	40	423	38	557
SCHOOL OF ENGINEERING												
Aeronautics and Astronautics, XVI	78	53	45	192	-	368	90	65	52	185	-	392
Aeronautics and Astronautics, XVI-B (Cooperative)	-	6	2	-	-	8	-	4	5	-	-	9
Aeronautics and Astronautics, XVI-C (Internship)	-	12	8	-	-	20	1	10	11	-	-	22
Chemical Engineering, X	95	108	107	206	-	516	127	98	110	231	-	566
Chemical Engineering, X-C (Cooperative)	4	1	4	-	-	9	-	6	4	-	-	10
Civil Engineering, I	23	34	48	290	2	397	20	30	40	257	1	348
Civil Engineering, I-A	1	-	1	-	-	2	-	1	1	-	-	2
Civil Engineering, I-W (Woods Hole)	-	-	-	3	-	3	-	-	-	5	-	5
Electrical Engineering and Computer Science, VI												
Program 1-Electrical Science and Engineering	250	158	168	568	2	1,449	236	167	181	551	-	1,46
Program 3-Computer Science and Engineering	100	111	92				97	108	123			
Electrical Engineering and Computer Science, VI-A (Cooperative)												
Program 1-Electrical Science and Engineering	-	65	83	74	-	266	-	62	70	90	-	272
Program 3-Computer Science and Engineering	-	20	24				-	22	28			
Electrical Engineering and Computer Science, VI-W (Woods Hole)	-	-	-	1	-	1	-	-	-	3	-	3
Materials Science and Engineering, III	24	23	23	213	-	283	30	18	23	242	-	313
Materials Science and Engineering, III-A	1	-	4	-	-	5	1	2	3	-	-	6
Materials Science and Engineering, III-B (Cooperative)	8	24	19	-	-	51	24	22	25	-	-	71
Materials Science and Engineering, III-W (Woods Hole)	-	-	-	1	-	1	-	-	-	-	-	-
Mechanical Engineering, II	111	101	120	405	-	737	127	106	105	445	-	783
Mechanical Engineering, II-A	8	13	25	-	-	46	3	8	18	-	-	29
Mechanical Engineering, II-B (Internship)	-	17	19	-	-	36	-	15	24	-	-	39
Mechanical Engineering, II-T (Textile Technology)	-	-	-	1	-	1	-	-	-	1	-	1
Mechanical Engineering, II-W (Woods Hole)	-	-	-	1	-	1	-	-	-	1	-	1
Nuclear Engineering, XXII	10	15	4	156	-	185	12	4	13	156	-	185
Nuclear Engineering, XXII-A (Internship)	-	3	3	-	-	6	-	5	3	-	-	8
Ocean Engineering, XIII	12	6	15	95	-	128	10	11	6	88	-	115
Ocean Engineering, XIII-C (Cooperative)	-	-	1	-	-	1	-	-	-	-	-	-
Ocean Engineering, XIII-W (Woods Hole)	-	-	-	8	-	8	-	-	-	9	-	9
Naval Construction and Engineering, XIII-A	-	-	-	50	-	50	-	-	-	52	-	52
Ocean Systems Management, XIII-B	-	-	-	11	-	11	-	-	-	19	-	19
Center for Advanced Engineering Study, EN	-	-	-	54	-	54	-	-	-	55	-	55
Total	725	770	815	2,329	4	4,643	778	764	845	2,390	1	4,778
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE												
Economics, XIV	14	16	20	116	14	180	8	23	17	128	10	186
Humanities, XXI	-	-	-	-	-	-	-	-	-	-	-	-
Humanities and Engineering, XXI-E	1	3	2	-	-	6	-	1	7	-	-	8
Humanities and Science, XXI-S	3	11	17	-	-	31	4	13	23	-	-	40
Linguistics and Philosophy, XXIV	2	1	4	61	9	77	-	5	5	56	9	75
Political Science, XVII	7	9	12	106	28	162	-	9	18	130	28	185
Political Science, XVII-A (Public Policy)	-	2	4	-	-	6	-	-	2	-	-	2
Psychology, IX	-	-	-	35	-	35	-	-	-	31	-	31
Total	27	42	59	318	51	497	12	51	72	345	47	527
SLOAN SCHOOL OF MANAGEMENT												
Management, XV	17	29	54	363	5	468	14	22	37	392	6	471
Management Fellows, XV-A	-	-	-	62	-	62	-	-	-	76	-	76
Management-Operations Research, XV-B	-	-	-	17	-	17	-	-	-	14	-	14
Total	17	29	54	442	5	547	14	22	37	482	6	561
SCHOOL OF SCIENCE												
Biology, VII	49	48	56	133	-	286	36	51	50	132	-	269
Biology, VII-A	-	9	14	-	-	23	4	3	12	-	-	19
Biology, VII-B	9	11	8	-	-	28	6	13	11	-	-	30
Biology, VII-W (Woods Hole)	-	-	-	20	-	20	-	-	-	19	-	19
Chemistry, V	48	35	48	202	-	333	42	47	39	216	-	344
Earth and Planetary Sciences, XII	6	14	15	86	2	123	10	11	19	82	2	124
Earth and Planetary Sciences, XII-W (Woods Hole)	-	-	-	32	-	32	-	-	-	39	-	39
Interdisciplinary Science Program, XXV	2	5	2	23	-	32	3	2	2	11	-	18
Mathematics, XVIII	43	40	41	121	5	250	37	48	52	115	9	261
Meteorology and Physical Oceanography, XIX	-	-	-	46	-	46	-	-	-	49	1	50
Meteorology and Physical Oceanography, XIX-W (Woods Hole)	-	-	-	13	-	13	-	-	-	13	-	13
Nutrition and Food Science, XX	-	-	-	171	1	172	-	-	-	165	-	165
Physics, VIII	75	85	86	310	-	556	86	69	84	298	2	539
Total	232	247	270	1,157	8	1,914	224	244	269	1,139	14	1,890
Health Sciences and Technology, HST	-	-	-	52	-	52	-	-	-	63	-	63
Undesignated	99					99	96					96
First Year 1,095						1,095	1,038					1,038
Grand Total 1,095	1,119[2]	1,122[2]	1,241[2]	4,692	96	9,365	1,038	1,154[3]	1,107[3]	1,263[3]	4,842	106	9,510
(Not included in the above figures)												
Non-Institue students from Harvard	11	15	31	259	-	316	15	12	25	326	-	378
Non-Institute students from Tufts	-	-	-	-	-	-	-	-	-	-	-	-
Non-Institute from Wellesley	44	60	118	-	-	222	42	67	87	-	-	196

[1] Non-Resident students

[2] These totals include 8 students in third year and 4 students in fourth year on Foreign Study; 1 student in second year 2 students in third year, and 3 students in fourth year on Domestic Study.

[3] These totals include 8 students in third year, 2 students in fourth year on Foreign Study; 2 students in second year, 2 students in third year on Domestic Study.

[4] These totals include 7 students, in the third year, 2 students in the fourth year on Foreign Study, 1 student in the third year, 5 students in the fourth year on Domestic Study.

	1982-83						
2	3	4	G	Non Res.[1]	Total	COURSE NUMBER
17	23	32	236	6	314	IV
-	1	-	-	-	1	IV-B
1	1	5	169	33	209	XI
18	25	37	405	39	524	Total
84	74	68	204	-	430	XVI
-	-	5	-	-	5	XVI-B
-	10	8	-	-	18	XVI-C
133	113	103	208	-	557	X
-	7	7	-	-	14	X-C
18	32	35	221	8	314	I
-	1	2	-	-	3	I-A
-	-	-	8	-	8	I-W
243	192	180)	548	1	1,486	VI
102	83	137)				
-	50	75)	85	-	264	VI-A
-	27	27)				
-	-	-	3	-	3	VI-W
9	15	18	216	2	260	III
1	1	5	-	-	7	III-A
12	32	29	-	-	73	III-B
-	-	-	-	-	-	III-W
127	118	123	422	4	794	II
3	9	14	-	-	26	II-A
-	18	15	-	-	33	II-B
-	-	-	1	-	1	II-T
-	-	-	1	-	1	II-W
11	8	6	164	1	190	XXII
-	3	5	-	-	8	XXII-A
10	12	16	104	-	142	XIII
-	-	-	-	-	-	XIII-C
-	-	-	9	-	9	XIII-W
-	-	-	60	-	60	XIII-A
-	-	-	12	-	12	XIII-B
-	-	-	50	-	50	EN
753	805	878	2,316	16	4,768	Total
11	11	26	133	3	184	XIV
1	2	9	-	-	12	XXI
1	-	12	-	-	13	XXI-E
2	4	6	-	-	12	XXI-S
3	1	3	47	14	68	XXIV
4	9	11	129	34	187	XVII
1	1	2	-	-	4	XVII-A
5	3	3	27	-	38	IX
28	31	72	336	51	518	Total
11	21	37	426	6	501	XV
-	-	-	65	-	65	XV-A
-	-	-	6	-	6	XV-B
11	21	37	497	6	572	Total
44	50	45	139	-	278	VII
2	8	13	-	-	23	VII-A
9	7	18	-	-	34	VII-B
-	-	-	19	-	19	VII-W
32	37	47	193	5	314	V
11	16	13	82	2	124	XII
-	-	-	38	-	38	XII-W
-	-	1	2	-	3	XXV
36	36	56	106	14	248	XVIII
-	-	-	42	1	43	XIX
-	-	-	16	-	16	XIX-W
-	-	-	159	3	162	XX
57	82	74	302	3	518	VIII
191	236	267	1,098	28	1,820	Total
-	-	-	64	-	64	HST
92	-	-	-	-	92	Undesignated
1,117					1,117	First Year
1,117	1,093	1,118[4]	1,291[4]	4,716	140	9,475	Grand Total
22	5	24	308	-	359	NIH
14	1	-	-	-	15	NIT
35	49	68	-	-	152	NIW

TABLE III-A WOMEN STUDENTS BY SCHOOLS, COURSES AND YEARS, 1982-83[1]

COURSE	2	3	4	GRADUATE REGULAR	GRADUATE NON RESIDENT	GRADUATE SPECIAL	TOTAL
SCHOOL OF ARCHITECTURE AND PLANNING							
Architecture, IV	7	11	9	61	4	1	93
Urban Studies and Planning, XI	-	1	4	71	16	11	103
Total	7	12	13	132	20	12	196
SCHOOL OF ENGINEERING							
Aeronautics and Astronautics, XVI	15	7	12	11	-	2	47
Aeronautics and Astronautics, XVI-C (Internship)	-	3	-	-	-	-	3
Chemical Engineering, X	37	40	27	35	-	1	140
Chemical Engineering, X-C (Cooperative)	-	1	2	-		-	3
Civil Engineering, I	7	8	11	24	-	4	54
Civil Engineering, I-W (Woods Hole)	-	-	-	1	-	-	1
Electrical Engineering and Computer Science, VI							
Program 1-Electrical Science and Engineering	35	26	25	60	-	12	209
Program 3-Computer Science and Engineering	12	17	22				
Electrical Engineering and Computer Science, VI-A (Cooperative)							
Program 1-Electrical Science and Engineering	-	9	4	6	-	-	24
Program 3-Computer Science and Engineering	-	4	1				
Materials Science and Engineering, III	3	8	10	36	-	2	59
Materials Science and Engineering, III-A	1	1	3	-	-	-	5
Materials Science and Engineering, III-B (Cooperative)	5	13	11	-	-	-	29
Mechanical Engineering. II	32	31	21	26	-	5	115
Mechanical Engineering, II-A	3	4	6	-	-	-	13
Mechanical Engineering, II-B (Internship)	-	2	2	-	-	-	4
Nuclear Engineering, XXII	2	-	-	12	-	-	14
Nuclear Engineering, XXII-A (Internship)	-	1	-	-	-	-	1
Ocean Engineering, XIII	1	2	-	3	-	2	8
Naval Construction and Engineering, XIII-A	-	-	-	3	-	-	3
Ocean Systems Management, XIII-B	-	-	-	-	-	-	-
Center for Advanced Engineering Study, EN	-	-	-	-	-	1	1
Total	153	177	157	217	-	29	733
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE							
Economics, XIV	4	1	2	23	-	3	33
Humanities, XXI	1	-	3	-	-	-	4
Humanities and Engineering, XXI-E	-	-	4	-	-	-	4
Humanities and Science, XXI-S	2	1	-	-	-	-	3
Linguistics and Philosophy, XXIV	2	-	-	20	5	-	27
Political Science, XVII	2	-	6	34	12	-	54
Political Science, XVII-A (Public Policy)	-	-	-	-	-	-	-
Psychology, IX	2	3	1	9	-	-	15
Total	13	5	16	86	17	3	140
SLOAN SCHOOL OF MANAGEMENT							
Management, XV	5	6	8	107	2	3	131
Management Fellows, XV-A	-	-	-	6	-	1	7
Management-Operations Research, XV-B	-	-	-	1	-	-	1
Total	5	6	8	114	2	4	139
SCHOOL OF SCIENCE							
Biology, VII	21	24	12	39	-	3	99
Biology, VII-A	1	2	3	-	-	-	6
Biology, VII-B	7	2	8	-	-	-	17
Biology, VII-W (Woods Hole)	-	-	-	9	-	-	9
Chemistry, V	10	10	13	48	2	1	84
Earth and Planetary Sciences, XII	4	6	3	14	2	-	29
Earth and Planetary Sciences, XII-W (Woods Hole)	-	-	-	13	-	-	13
Interdisciplinary Science Program, XXV	-	-	1	1	-	-	2
Mathematics, XVIII	9	8	9	19	3	1	49
Meteorology and Physical Oceanography, XIX	-	-	-	6	-	-	6
Meteorology and Physical Oceanography, XIX-W (Woods Hole)	-	-	-	7	-	-	7
Nutrition and Food Science, XX	-	-	-	67	1	2	70
Physics, VIII	13	10	1	34	-	2	60
Total	65	62	50	257	8	9	451
Health Sciences and Technology, HST	-	-	-	4	-	15	19
Undesignated	33	-	-	-	-	-	33
First Year	266						266
Grand Total	266	276	262	244	810	47	72	1,977

[1]Also included in Table III
Total undergraduate women 1,048; 19 special undergraduate women are included.

TABLE III-B SPECIAL STUDENTS BY SCHOOLS, COURSES AND YEARS, 1982-83[1]

COURSE	2	3	4	G	TOTAL
SCHOOL OF ARCHITECTURE AND PLANNING					
Architecture, IV	-	1	1	5	7
Urban Studies and Planning, XI	-	-	-	25	25
Total	-	1	1	30	32
SCHOOL OF ENGINEERING					
Aeronautics and Astronautics, XVI	-	-	1	16	17
Chemical Engineering, X	-	-	-	1	1
Civil Engineering, I	-	1	-	15	16
Electrical Engineering and Computer Science, VI, VI-1, VI-3	1	1	4	68	74
Materials Science and Engineering, III	-	-	-	10	10
Mechanical Engineering. II	-	-	-	56	56
Nuclear Engineering, XXII	-	-	-	-	-
Ocean Engineering, XIII	-	-	-	10	10
Center for Advanced Engineering Study, EN	-	-	-	50	50
Total	1	2	5	226	234
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE					
Economics, XIV	-	-	-	6	6
Humanities, XXI, XXI-E, XXI-S	-	-	1	-	1
Linguistics and Philosophy, XXIV	1	-	-	3	4
Political Science, XVII	1	-	-	7	8
Psychology, IX	-	-	-	-	-
Total	2	-	1	16	19
SLAON SCHOOL OF MANAGEMENT					
Management, XV, XV-A, XV-B	-	-	-	22	22
SCHOOL OF SCIENCE					
Biology, VII, VII-A, VII-B	1	-	1	5	7
Chemistry, V	-	-	-	1	1
Earth and Planetary Sciences, XII	-	-	1	-	1
Interdisciplinary Science Program, XXV	-	-	-	-	-
Mathematics, XVIII	2	-	6	6	14
Meteorology and Physical Oceanography, XIX	-	-	-	1	1
Nutrition and Food Science, XX	-	-	-	5	5
Physics, VIII	-	-	-	10	10
Total	3	-	8	28	39
Health Sciences and Technology, HST	-	-	-	45	45
Undesignated	23	-	-	-	23
Grand Total	29	3	15	367	414

[1]Included also in Table III

TABLE IV CONTINUED, FORMER, AND NEW STUDENTS

	1978-79	1979-80	1980-81	1981-82	1982-83
CONTINUED STUDENTS					
Undergraduate and Graduate students registered at the end of the last academic year (including special students)	6,122	6,260	6,554	6,828	6,791
NON-CONTINUED STUDENTS					
Former undergraduate and graduate students who previously attended the Institute but were not registered at the end of the last academic year (including special students).	311	353	286	280	208
Undergraduate students who enrolled for the first time since secondary school (excluding special students).	1,055	1,055	1,089	1,029	1,108
Undergraduate students who enrolled for the first time at the Institute and who transferred from other collegiate institutions (excluding special students).	120	105	94	74	84
Graduate students who enrolled for the first time at the Institute (excluding special students).	1,025	1,011	1,077	1,033	1,072
Special undergraduate and graduate students with no previous Institute registration.	248	269	265	266	212
	8,881	9,053	9,363	9,510	9,475

TABLE V REGULAR STUDENTS FROM OTHER COLLEGES AND GRADUATES OF M.I.T. CLASSIFIED BY SCHOOLS AND COURSES 1982-83

	Entered with no previous degree	Entered with Bachelor's degree from other colleges	Entered Graduate School with Bachelor's degree from M.I.T.
SCHOOL OF ARCHITECTURE AND PLANNING			
Architecture (IV, IV-B)	9	207	30
Urban Studies and Planning (XI)	-	163	14
TOTAL	9	370	44
SCHOOL OF ENGINEERING			
Aeronautics and Astronautics (XVI)	18	138	50
Chemical Engineering (X,X-C)	17	178	29
Civil Engineering (1, 1-W)	15	202	20
Electrical Engineering and Computer Science (VI, VI-1, VI-3, VI-W)	77	280	289
Materials Science and Engineering (III)	-	172	36
Mechanical Engineering (II, II-A, II-B, II-W)	41	272	100
Nuclear Engineering (XXII, XXII-A)	4	142	23
Ocean Engineering (XIII, XIII-A, XIII-B, XIII-W)	8	163	12
Total	180	1,547	559
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE			
Economics (XIV)	5	126	4
Humanities and Engineering or Science (XXI, XXI-E, XXI-S)	1	-	-
Linguistics and Philosophy (XXIV)	-	56	2
Political Science (XVII)	1	139	17
Psychology (IX)	-	21	6
Total	7	342	29
SLOAN SCHOOL OF MANAGEMENT			
Management (XV, XV-A, XV-B)	3	424	57
SCHOOL OF SCIENCE			
Biology (VII, VII-A, VII-B, VII-W)	6	147	6
Chemistry (V)	9	195	2
Earth and Planetary Sciences (XII, XII-W)	-	112	10
Interdisciplinary Science Program (XXV)	-	1	1
Mathematics (XVIII)	12	105	9
Meteorology and Physical Oceanography (XIX, XIX-W)	-	54	4
Nutrition and Food Science (XX)	-	140	17
Physics (VIII)	20	237	58
Total	47	991	107
HEALTH SCIENCES AND TECHNOLOGY	-	15	4
FIRST YEAR	3		
Grand total	249	3,689	800

TABLE VI LIST OF COLLEGES AND UNIVERSITIES WITH NUMBER OF GRADUATES ENTERING THE INSTITUTE AS REGULAR STUDENTS[1]

Air Force Institute of Technology	1	Hampshire College	4
American University	1	Harvard University	27
Amherst College	5	Harvey Mudd College	3
Antioch College	1	Haverford College	1
Arizona, University of	6	Hawaii, University of	4
Auburn University	1	Hofstra University	1
Bates College	2	Holy Cross, College of the	4
Belmont College	1	Houston, University of	2
Beloit College	2	Howard University	3
Boston Architectural Center	1	Illinois Institute of Technology	1
Boston College	7	Illinois, University of, Chicago Circle	1
Boston State College	1	Illinois, University of, Urbana-Champaign	9
Boston University	12	Indiana University, Bloomington	4
Bowdoin College	3	Iowa State University of Science and Technology	2
Bowling Green State University	1	Iowa, University of	2
Bradley University	1	Johns Hopkins University	7
Brandeis University	7	Kansas State University	2
Brown University	14	Kenyon College	1
Bucknell University	1	Lehigh University	4
California Institute of Technology	11	Louisiana State University	2
California Polytechnic State University, San Luis Obispo	3	Louisville, University of	1
California State College, San Bernardino	1	Lowell, University of	1
California State Polytechnic University, Pomona	1	Loyola, University of, Chicago	2
California State University, Fresno	1	Loyola Marymount University	1
California State University, Humbolt	2	Lyndon State College	1
California, University of, Berkeley	17	Maine, University of, Orono	1
California, University of, Davis	5	Marquette University	1
California, University of, Irvine	1	Maryland, University of, College Park	1
California, University of, Los Angeles	4	Maryland, University of, Baltimore County	1
California, University of, Riverside	1	Massachusetts College of Art	1
California, University of, San Diego	4	Massachusetts, University of, Amherst	18
California, University of, Santa Barbara	8	Massachusetts, University of, Boston	3
California, University of, Santa Cruz	2	Massachusetts Institute of Technology	229
Canisius College (New York)	1	Miami University	2
Carleton College	1	Michigan State University	4
Carnegie-Mellon University	8	Michigan Technological University	2
Case Western Reserve University	4	Michigan, University of, Ann Arbor	11
Central Washington State College	1	Michigan, University of, Flint	1
Chicago, University of	5	Middlebury College	3
Cincinnati, University of	5	Minneapolis College of Art and Design	1
City College, New York	2	Minnesota, University of	8
Clark University	3	Mississippi State University	1
Clarkson College of Technology	1	Missouri, University of, Columbia	1
Clemson University	1	Missouri, University of, Rolla	1
Cleveland Institute of Art	1	Morgan State College	1
Colby College	4	Mount Holyoke College	1
Colgate University	2		
Colorado School of Mines	1	Nebraska, University of	2
Colorado State University	4	New College	1
Colorado, University of	4	New Hampshire, University of	3
Columbia University	9	New Jersey Institute of Technology	1
Concordia College	1	New Mexico Institute of Mining and Technology	1
Connecticut College	1	New York University	2
Connecticut, University of	5	New York, City University of	1
Cooper Union	5	New York, Polytechnic Institute of	8
Cornell University	19	New York, State of, Downstate Medical Center	1
Dartmouth College	5	New York, State University of, Albany	2
Dayton, University of	2	New York, State University of, Binghampton	1
Delaware, University of	2	New York, State University of, Buffalo	3
Drexel University	3	New York, State University of, Stonybrook	6
Duke University	7	New York, State University College of, at Buffalo	2
Eckerd College	1	New York, State University College, of Environmental Science and Forestry	1
Evergreen State College, The	1	North Carolina State University, Raleigh	3
Fairfield University	1	North Carolina, University of, Chapel Hill	2
Florida Agricultural and Mechanical University	1	North Dakota State University	1
Florida Atlantic University	2	North Dakota, University of	1
Florida Institute of Technology	1	North Texas State University	1
Florida Technological University	1	Northeastern University	8
Florida, University of	2	Northern Colorado, University of	1
General Motors Institute	6	Northern Illinois University	1
George Washington University	4	Northern Kentuckey State College	1
Georgetown University	1	Northwestern University	7
Georgia Institute of Technology	7	Norwich University	1
		Notre Dame, University of	2

Oberlin College	4
Ohio State University	2
Oklahoma, University of	2
Oregon, University of	2
Pacific Union College	1
Pennsylvania State University	3
Pennsylvania, University of	6
Philadelphia College of Textiles and Science	1
Pittsburgh, University of	1
Pitzer College	1
Plymouth State College	1
Point Loma College	1
Pomona College	3
Pratt Institute	1
Princeton University	16
Purdue University	13
Queens College	1
Radcliffe College	2
Reed College	4
Rensselaer Polytechnic Institute	11
Rhode Island School of Design	4
Rhode Island, University of	7
Rice University	1
Rochester Institute of Technology	2
Rochester, University of	3
Rockefeller University	1
Rose-Hulmen Institute of Technology	1
Rutgers, The State University	1
San Jose State University	1
Santa Clara, University of	1
Smith College	4
South Carolina, University of	1
South Dakota State University	1
South Florida, University of	2
Southeastern Massachusetts University	1
Southern California Institute of Architecture	1
Southern California, University of	5
Southern Methodist University	1
Southern University and Agricultural and Mechanical College	1
St. John Fisher College	1
Stanford University	18
Stephens College	1
Stevens Institute of Technology	1
Suffolk University	2
Swarthmore College	6
Syracuse University	4
Temple University	1
Tennessee Technological University	1
Tennessee, University of, Knoxville	1
Texas A & M University	4
Texas Tech University	1
Texas, University of, Austin	9
Trenton State College	1
Trinity College, Connecticut	1
Tufts University	8
Tulane University	1
U.S. Air Force Academy	8
U.S. Coast Guard Academy	2
U.S. Merchant Marine Academy	2
U.S. Military Academy	8
U.S. Naval Academy	10
Vanderbilt University	1
Vassar College	1
Vermont, University of	3
Virginia Polytechnic Institute and State University	3
Virginia, University of	1
Washington and Lee University	1
Washington University	7
Washington, University of	10
Webb Institute of Naval Architecture	2
Wellesley College	4
Wesleyan University	4
West Virginia University	2
Wheaton College, Massachusetts	1
Whitman College	1
Wichita State University	1
William and Mary, College of	2
Williams College	6
Wisconsin, University of, Madison	6
Wittenberg University	1
Worcester Polytechnic Institute	9
Yale University	17
U.S. Territories and Dependencies	
Puerto Rico, University of, Mayaguez	4
Total United States	1,004
Academia Militar (Portugal)	1
Ahmadu Bello University (Nigeria)	1
Al-Jami Ah Al-Amirikyah Fi Bayrut (Lebanon)	1
Alberta, University of (Canada)	1
Aristotelion Panepistimion Thessalonikis (Greece)	2
Arteneo de Manila University (Phillipines)	1
Auckland, University of (New Zealand)	2
Australian National University (Australia)	1
Bangladesh University of Engineering and Technology (Bangledesh)	1
Birmingham, University of (England)	2
Bogazici Universitesi (Turkey)	1
Bristol, University of (England)	1
British Columbia, University of (Canada)	2
Cairo University (Egypt)	2
Cambridge, University of (England)	5
Canterbury, University of (New Zealand)	1
Carleton University (Canada)	2
Chulalongkorn University (Thailand)	1
Chung-Yuan College of Science and Engieering (Taiwan,China)	1
City University (England)	1
Den Polytekniske Laereanstalt Danmarks Tekniske Hojskole (Denmark)	1
Ecole Centrale de Paris (France)	1
Ecole Centrale des Arts et Manufactures (France)	6
Ecole Nationale des Ponts et Chaussees (France)	9
Ecole Nationale des Travoux Publics de I'Etat Vauex (France)	2
Ecole Nationale Superieure d'Arts et Metiers (France)	2
Ecole Nationale Superieure de l'Aeronartique et de l'Espace (France)	1
Ecole Nationale Superieure de Mecanique (France)	2
Ecole Nationale Superieure de Techniques Avancees (France)	1
Ecole Nationale Superieure des Mines de Paris (France)	1
Ecole Polytechnique (France)	1
Ecole Polytechnique d'Architecture et d'Urbanisme (Algeria)	1
Ecole Polytechnique Federale de Lausanne (Switzerland)	2
Edinburgh, University of (Scotland)	1
Eidgenassische Technische Hochschule Zurich (Switzerland)	1
Escuela Naval del Peru (Peru)	1
Escuela Technica Superior de Ingenieros Navales (Spain)	1
Ethnikon Metsovion Polytechneion Athinai (Greece)	3
Friedrich-Alexander-Universitat Erlangen-Nurnberg (West Germany)	1
Fudan University (China)	1
Geological College of Chang Chun (China)	1
Glasgow, University of (Scotland)	3
Ha'Technion-Machon Technologi le Israel (Israel)	2
Ha'Universita Ha'Lvrith Birushalayim (Israel)	2
Hitotsubashi University (Japan)	1
Huaghong Institute of Science and Technology (China)	1

Imperial College of Science and Technology (England)	6
Ife, University of (Nigeria)	2
Indian Institute of Management (India)	1
Indian Institute of Technology (Kanpur,India)	1
Indian Institute of Technology (Khargpur,India)	1
Indian Institute of Technology (Madras,India)	3
Indian Institute of Technology (New Delhi,India)	1
Indian Institute of Technology (West Bengal,India)	1
Instituto Politecnico Nacional (Mexico)	1
Instituto Technologico Autonomo de Mexico (Mexico)	1
Instituto Technologico de Aeronautica (Brazil)	2
Instituto Technologico y de Estudios Superiores (Mexico)	2
Institutul de Architectura Ion Mincu (Romania)	1
Interuniverstire Interfaculteit voor Bedrijfskunde (Netherlands)	1
Jami at Baghas (Iraq)	1
Kabul Pohantoon (Afghanistan)	1
Kobe Daigaku (Japan)	1
Kokusai Kirisutokyo Daigaku (Japan)	1
Korea Advanced Institute of Science (South Korea)	5
Kungliga Teknisha Hogskolan (Sweden)	2
Kyota Daigaku (Japan)	2
La Trobe University (Australia)	1
Lagos, University of, (Nigeria)	1
Lakehead University (Canada)	1
London School of Economics and Political Science (England)	2
London, University of, (England)	1
Loughborough Institute of Technology (England)	1
McGill University (Canada)	4
Memorial University of New Foundland (Canada)	2
Moscow State University (U.S.S.R.)	1
Nagoya Daigaku (Japan)	1
National Cheng Kung University (Taiwan, China)	1
National Chiao-Tung University (Taiwan, China)	1
National Institute of Design (Gujarat, India)	1
National Taiwan University (Taiwan, China)	10
National Tsing Hua University (Taiwan, China)	2
NED University of Engineering and Technology (Pakistan)	2
New Brunswick, University of, (Canada)	1
Newcastle Upon Tyne, University of, (England)	3
Norges Tekniske Hogskole (Norway)	1
Norwegian Institute of Technology (Norway)	1
Nova Scotia College of Art and Design (Canada)	1
Orta Doku Teknik Universitesi (Turkey)	1
Osaka Daigaku (Japan)	2
Osaka Yakka Daigaku (Japan)	1
Oxford, University of, (England)	3
Pamantasan ng Philipinas (Philippines)	1
Peking University (China)	3
Peshawar, University of, (Pakistan)	1
Politechnika Gdanska (Poland)	1
Politechnika Warszawska (Poland)	1
Pontificia Universidad Catalica del Peru (Peru)	1
Pontificia Universidad Catalica do Rio de Janeiro (Brazil)	2
Poona, University of, (India)	1
Queen's University at Kingston (Canada)	4
Rheinisch-Westfalische Hochschule (West Germany)	1
Rheinische Friedrich-Wilhelms Universitat, Bonn (West Germany)	1
School of Architecture (India)	3
School of Planning and Architecture (India)	1
Science and Technology of China, University of, (China)	1
Science and Technology, University of, Kumasi (Ghana)	1
Seoul Dae Hag Gyo (South Korea)	11
Singapore, University of, (Singapore)	4
Sogang Dae Hay Gyo (South Korea)	1
Southampton, University of, (England)	1
Sydney, University of, (Australia)	1
Tamkang College of Arts and Sciences (Taiwan, China)	1
Tohoku Daigaku (Japan)	1
Tokyo Daigaku (Japan)	14
Tokyo Kogyo Daigaku (Japan)	1
Tsinghua University (China)	1
Unite Pedagogique d'Architecture (France)	2
Universidad Anahuac (Mexico)	1
Universidad Catolica de Chile (Chile)	2
Universidad Central de Venezuela (Venezuela)	1
Universidad Centroamericana "Jose Simeon Canas" (El Salvador)	1
Universidad de Buenas Aires (Argentina)	3
Universidad de Costa Rica (Costa Rica)	2
Universidad del Zulia (Venezuela)	1
Universidad Iberoamericana (Mexico)	2
Universidad la Salle (Mexico)	1
Universidad Metropolitana (Venezuela)	2
Universidad Nacional Autonoma de Mexico (Mexico)	3
Universidad Nacional de Ingenieria (Peru)	2
Universidad Nacional de la Plata (Argentina)	1
Universidad Nacional del Sur Bahia Blanca (Argentina)	1
Universidad Simon Bolivar (Venezuela)	2
Universidade de Sao Paulo (Brazil)	3
Universidade Federal do Rio de Janeiro (Brazil)	2
Universita degli Studi di Bologna (Italy)	3
Universita degli Studi di Cagliari (Italy)	1
Universitat Fridericiana Karlsruhe (West Germany)	1
Universitat Wein (Austria)	1
Universitat Zurich (Switzerland)	1
Universite de Montreal (Canada)	4
Universite de Paris VI (France)	1
Universite de Paris VII (France)	1
Universite de Paris Val-de-Marne (France)	1
Universite Mohammed V (Morocco)	1
Universiteit van Amsterdam (Netherlands)	1
Universitetet i Bergen (Norway)	1
Universitetet i Trondheim (Norway)	1
University College (England)	2
University College, Dublin (Ireland)	1
Univerzitet u Beogradu (Yugoslavia)	2
Uniwersytet Jagiellonski (Poland)	1
Victoria University of Manchester (England)	3
Waseda Daigaku (Japan)	3
Waterloo, University of, (Canada)	1
West Indies, University of, Mona (Jamaica)	1
Western Ontario, University of, (Canada)	1
Wilfred Laurier University (Canada)	1
Winnipeg, University of, (Canada)	1
Witwatersand, University of, (South Africa)	1
Wuhan Institute of Water Transportation Engineering (China)	1
Zambia, University of, (Zambia)	1
Total Foreign	291
Grand Total	1,295

[1]Graduates of 230 Colleges and Universities, including U.S.Territories and Dependencies in the United States, and 163 Foreign Colleges and Universities.

TABLE VII GEOGRAPHIC DISTRIBUTION OF STUDENTS, 1982-83

	Under-grad.	Grad.
UNITED STATES		
Alabama	19	10
Alaska	6	3
Arizona	25	16
Arkansas	10	1
California	281	330
Colorado	53	39
Connecticut	162	107
Delaware	10	11
District of Columbia	12	44
Florida	99	67
Georgia	49	27
Hawaii	21	1
Idaho	4	4
Illinois	162	107
Indiana	30	32
Iowa	15	13
Kansas	23	8
Kentucky	26	8
Louisiana	28	15
Maine	39	15
Maryland	127	91
Massachusetts	519	816
Michigan	85	93
Minnesota	58	43
Mississippi	10	4
Missouri	33	22
Montana	9	2
Nebraska	16	6
Nevada	1	-
New Hampshire	43	22
New Jersey	336	151
New Mexico	9	14
New York	817	450
North Carolina	34	29
North Dakota	6	1
Ohio	135	122
Oklahoma	24	11
Oregon	44	21
Pennsylvania	204	154
Rhode Island	26	24
South Carolina	11	20
South Dakota	4	3
Tennessee	25	20
Texas	120	79
Utah	6	15
Vermont	19	22
Virginia	96	98
Washington	53	51
West Virginia	9	8
Wisconsin	51	49
Wyoming	6	1
U.S. Territories and Dependencies		
Canal Zone	-	1
Puerto Rico	25	18
Virgin Islands	3	-
U. S. Citizens		
Foreign Address	56	61
Total U. S.	4,094	3,394

	Under-grad.	Grad.
FOREIGN COUNTRIES*		
Afghanistan	-	1
Algeria	1	8
Argentina	3	21
Australia	5	15
Austria	-	2
Bahrain	-	1
Bangladesh	-	9
Barbados	1	-
Belgium	1	12
Bolivia	-	3
Brazil	2	48
Brunei	1	-
Canada	57	105
Chile	2	11
China	8	31
Taiwan, China	35	105
Colombia	5	10
Costa Rica	1	2
Cuba	2	-
Cyprus	4	6
Denmark	-	2
Dominican Republic	2	-
Ecuador	-	2
Egypt	2	21
El Salvador	-	2
Ethiopia	-	1
Finland	1	6
France	3	70
Germany	6	19
Ghana	8	4
Greece	13	72
Guam	3	-
Guatemala	1	-
Guyana	6	2
Haiti	-	1
Honduras	-	1
Hong Kong	38	43
Iceland	-	1
India	33	91
Indonesia	1	5
Iran	15	36
Iraq	1	5
Ireland	1	4
Israel	4	24
Italy	8	21
Ivory Coast	-	1
Jamaica	4	2
Japan	22	95
Jordan	-	2
Kenya	1	2
Korea	41	103
Lebanon	5	25
Luxembourg	1	1
Malaysia	24	22
Mexico	9	45
Morocco	-	4
Nepal	1	1
Netherlands	2	10
Netherlands Antilles	2	2
New Zealand	-	7
Nicaragua	1	2
Nigeria	1	15
Norway	1	8
Pakistan	12	13
Panama	1	2
Paraguay	-	3
Peru	1	10
Philippines	4	15
Poland	2	5
Portugal	1	6
Rwanda	-	1
Rumania	1	-
Saudi Arabia	2	7
Singapore	9	16
South Africa	5	6
Spain	4	13
Sri Lanka	4	7
St. Vincent	1	-
Sudan	-	2
Sweden	4	9
Switzerland	-	8
Syria	1	-
Tanzania	1	-
Thailand	3	8
Trinidad	4	4
Tunisia	-	1
Turkey	5	29
Uganda	-	1
United Kingdom	35	58
Uruguay	-	4
U.S.S.R.	1	-
Venezuela	5	32
Vietnam	13	7
Yugoslavia	-	10
Zaire, Republic of	-	1
Zambia	1	2
Stateless	16	12
Total Foreign	525	1,462
Grand Total	4,619	4,856

*Country of Citizenship

TABLE VIII NUMBER OF DEGREES AWARDED IN SEPTMBER 1982, FEBRUARY 1983, AND MAY 1983

	S.B.			S.M.			M.Arch. M.C.P.			Engineer			Ph.D.			Sc.D.			Total		
	SEP	FEB	MAY	SEP	FEB	MAY	SEP	FEB	MAY	SEP	FEB	MAY	SEP	FEB	MAY	SEP	FEB	MAY	SEP	FEB	MAY
SCHOOL OF ARCHITECTURE AND PLANNING																					
Architecture	-	-	-	-	-	-	12	3	20	-	-	-	-	1	1	-	-	-	12	4	21
Architecture Studies	-	-	-	1	3	29	-	-	-	-	-	-	-	-	-	-	-	-	1	3	29
Art and Design	-	8	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	21
Visual Studies	-	-	-	4	1	13	-	-	-	-	-	-	-	-	-	-	-	-	4	1	13
Urban Studies and Planning	-	1	3	-	-	-	5	5	29	-	-	-	-	3	5	-	-	-	5	9	37
TOTAL	-	9	24	5	4	42	17	8	49	-	-	-	-	4	6	-	-	-	22	25	121
SCHOOL OF ENGINEERING																					
Aeronautics and Astronautics	2	10	61	13	22	31	-	-	-	-	-	-	3	5	8	-	2	2	18	39	102
Ceramics	-	-	-	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	3
Chemical Engineering	2	9	83	6	13	8	-	-	-	1	1	4	2	5	2	3	4	2	14	32	99
Undesignated	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
Chemical Engineering Practice	-	-	-	17	12	10	-	-	-	-	-	-	-	-	-	-	-	-	17	12	10
Civil Engineering	1	5	27	20	12	26	-	-	-	1	-	3	2	3	5	6	1	-	30	21	61
Undesignated	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Computer Science and Engineering	13	27	96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	27	96
Electrical Engineering	27	34	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	34	141
Electrical Engineering and Computer Science	-	-	-	38	51	65	-	-	-	5	9	14	10	7	10	2	3	2	55	70	91
Materials Engineering	-	-	-	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	3
Materials Science	-	-	-	1	1	5	-	-	-	-	-	-	-	-	-	-	-	-	1	1	5
Materials Science and Engineering	-	10	28	-	-	-	-	-	-	-	-	1	6	7	7	2	4	4	8	21	40
Undesignated	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Mechanical Engineering	13	13	93	35	30	63	-	-	-	1	2	2	2	10	8	-	4	3	51	59	169
Undesignated	-	3	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	8
Metallurgy	-	-	-	3	3	7	-	-	-	-	-	-	-	-	-	-	-	-	3	3	7
Naval Architecture and Marine Engineering	-	-	6	2	2	11	-	-	-	-	-	-	-	-	-	-	-	-	2	2	17
Nuclear Engineering	2	2	8	5	8	15	-	-	-	1	1	2	3	8	2	1	-	1	12	19	28
Ocean Engineering	1	1	3	4	4	14	-	-	-	1	-	17	1	2	4	-	-	-	7	7	38
Ocean Systems Management	-	-	-	3	5	1	-	-	-	-	-	-	-	-	-	-	-	-	3	5	1
Polymerics	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3
Technology and Policy	-	-	-	5	6	9	-	-	-	-	-	-	-	-	-	-	-	-	5	6	9
Total	61	115	566	158	170	274	-	-	-	10	13	43	29	47	46	14	18	14	272	363	943

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																			
Cognitive Science	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Economics	1	2	21	-	-	1	-	-	-	-	-	-	8	6	12	-	-	-	9	8	34
Humanities and Engineering	-	2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	11
Humanities and Science	1	4	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	12
Linguistics	-	-	-	-	-	-	-	-	-	-	-	-	4	2	3	-	-	-	4	2	3
Philosophy	-	1	5	-	-	-	-	-	-	-	-	-	1	-	3	-	-	-	1	1	8
Political Science	-	-	8	2	10	8	-	-	-	-	-	-	1	7	7	-	-	-	3	17	23
Political Science:Public Policy	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Psychology	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	1
Total	3	9	60	3	10	9	-	-	-	-	-	-	14	16	26	-	-	-	20	35	95
SLOAN SCHOOL OF MANAGEMENT																			
Management	2	5	25	8	11	220	-	-	-	-	-	-	5	5	3	-	-	-	15	21	248
SCHOOL OF SCIENCE																			
Biochemical Engineering	-	-	-	4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	4	3	2
Biology	-	-	-	1	1	1	-	-	-	-	-	-	4	9	6	-	-	-	5	10	7
Undesignated	2	3	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	30
Chemistry	2	4	35	2	1	-	-	-	-	-	-	-	12	9	20	-	-	-	16	14	55
Earth and Planetary Sciences	2	1	10	1	-	1	-	-	-	-	-	-	3	4	4	-	-	1	6	5	16
Food Science and Technology	-	-	-	1	1	6	-	-	-	-	-	-	-	-	-	-	-	-	1	1	6
Interdisciplinary Science	-	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1
Life Sciences	2	10	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	10	34
Mathematics	-	9	47	-	2	3	-	-	-	-	-	-	7	2	12	-	-	-	7	13	62
Metabolism and Human Nutrition	-	-	-	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1
Meteorology and Physical Oceanography	-	-	-	-	1	5	-	-	-	-	-	-	3	4	1	-	-	1	3	5	7
Neural and Endocrine Regulation	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
Nutrition and Food Science	-	-	-	-	-	-	-	-	-	-	-	-	3	6	11	-	1	2	3	7	13
Nutritional Biochemistry and Metabolism	-	-	-	1	4	1	-	-	-	-	-	-	-	-	-	-	-	-	1	4	1
Physics	12	3	49	2	4	5	-	-	-	-	-	-	9	13	21	-	1	-	23	21	75
Toxicology	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total	20	30	206	16	22	27	-	-	-	-	-	-	41	47	75	-	2	4	77	101	312
Health Sciences and Technology	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	3
Management of Technology	-	-	-	-	1	8	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8
Operations Research	-	-	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1
Transportation	-	-	-	5	5	8	-	-	-	-	-	-	-	-	-	-	-	-	5	5	8
Without Course Specification	-	-	-	10	12	19	-	-	-	-	-	-	-	-	-	-	-	-	10	12	19
Awarded Jointly with Woods Hole Oceanographic Institution																			
Biology	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
Civil Engineering	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	1
Earth and Planetary Sciences	-	-	-	-	-	-	-	-	-	-	-	-	1	3	2	-	-	1	1	3	3
Electrical Engineering and Computer Science	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
Meteorology and Physical Oceanography	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1	-
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
Grand Total	86	168	881	206	237	608	17	8	49	10	13	44	93	123	161	14	22	19	426	571	1,762

TABLE IX NUMBER OF DEGREES OF BACHELOR OF SCIENCE AWARDED

All statistics are arranged by schools as of the current year. During the years 1868-1949 the general divisions were Architecture, Engineering, and Science. In 1959 the School of Humanities and Social Studies was established, and in 1951 the School of Industrial Management (after 1963 the Sloan School of Management) was added.

	Total by decade														Calendar year since 1979 (included in decade total)				
	1868-70	1871-80	1881-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1979	1980	1981	1982	1983*
SCHOOL OF ARCHITECTURE AND PLANNING[1]																			
Architecture	-	12	24	162	188	233	223	23	-	-	-	-	-	865	-	-	-	-	
Undesignated	-	-	-	-	-	-	-	-	-	-	2	18	1	21	1	-	-	1	-
Architectural Engineering[2]	-	-	-	-	-	-	108	64	-	-	-	-	-	172	-	-	-	-	-
Art and Design	-	-	-	-	-	-	-	-	-	-	26	436	88	543	36	33	29	23	29
Urban Studies	-	-	-	-	-	-	-	-	-	-	-	156	19	175	14	10	10	5	4
Undesignated	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-
Total	-	12	24	162	188	233	331	87	-	-	28	612	101	1,778	51	43	39	29	33
SCHOOL OF ENGINEERING																			
Aeronautics and Astronautics[11]	-	-	-	-	-	-	68	287	526	395	556	263	176	2,271	42	32	47	58	71
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Building Engineering and Construction	-	-	-	-	-	-	32	99	114	131	-	-	-	376	-	-	-	-	-
Chemical Engineering	-	-	-	91	123	372	571	434	740	726	421	502	300	4,280	95	100	99	109	92
Undesignated	-	-	-	-	-	-	-	-	-	-	3	91	25	119	13	17	10	8	7
Chemical Engineering Practice	-	-	-	-	-	-	99	90	95	108	1	-	-	393	-	-	-	-	-
Civil Engineering	12	84	86	256	407	504	653	284	272	457	252	499	113	3,879	62	62	41	40	32
Undesignated	-	-	-	-	-	-	-	-	-	-	7	26	3	36	3	1	1	-	2
Computer Science and Engineering	-	-	-	-	-	-	-	-	-	-	-	463	322	785	95	100	79	120	123
Electrical Engineering[3]	-	-	72	335	349	468	1,000	719	1,218	1,518	1,941	1,857	576	10,053	189	172	189	212	175
Undesignated	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	1	-	-	-
Electrochemical Engineering	-	-	-	-	28	84	133	56	-	-	-	-	-	301	-	-	-	-	-
General Engineering	-	-	-	-	-	6	226	222	230	133	-	-	-	817	-	-	-	-	-
Materials Science and Engineering[4]	-	-	-	-	-	-	-	52	194	311	186	162	118	1,023	22	36	32	48	38
Undesignated	-	-	-	-	-	-	-	-	-	-	1	26	11	38	4	1	5	2	4
Mechanical Engineering	5	40	147	329	502	623	797	602	1,164	1,049	563	671	332	6,824	129	105	119	107	106
Undesignated	-	-	-	-	-	-	-	-	-	-	12	143	49	204	16	24	22	16	11
Military Engineering	-	-	-	-	-	-	1	4	-	-	-	-	-	5	-	-	-	-	-
Mining Engineering and Metallurgy	8	44	64	74	250	129	174	137	-	-	-	-	-	880	-	-	-	-	-
Naval Arhitecture and Marine Engineering	-	-	-	43	133	69[+]	100	173	234	139	69	54	11	1,025	8	6	5	-	6
Nuclear Engineering	-	-	-	-	-	-	-	-	-	-	-	35	27	62	9	11	9	8	10
Ocean Engineering	-	-	-	-	-	-	-	-	-	-	-	58	22	80	6	10	11	7	4
Undesignated	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Sanitary Engineering	-	-	-	29	54	123	34	20	4	-	-	-	-	264	-	-	-	-	-
Total	25	168	369	1,157	1,846	2,378	3,888	3,179	4,791	4,967	4,012	4,854	2,085	33,719	693	678	669	735	681

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																			
Cognitive Science	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	3
Economics	-	-	-	-	-	-	-	-	-	-	129	260	60	449	23	21	17	20	23
Economics, Politics and Engineering or Science	-	-	-	-	-	-	-	-	61	152	100	-	-	313	-	-	-	-	-
Humanities and Engineering or Science[5]	-	-	-	-	-	-	-	-	-	49	412	323	67	851	18	25	18	20	29
Philosophy	-	-	-	-	-	-	-	-	-	-	-	37	15	52	2	6	5	4	6
Political Science[9]	-	-	-	-	-	-	-	-	-	-	114	129	34	277	9	8	12	14	8
Political Science: Public Policy	-	-	-	-	-	-	-	-	-	-	-	-	7	7	-	-	4	3	-
Total	-	-	-	-	-	-	-	-	61	201	755	749	186	1,952	52	60	56	61	69
SLOAN SCHOOL OF MANAGEMENT[6]																			
Business and Engineering Administration	-	-	-	-	-	142	872	641	909	732	-	-	-	3,296	-	-	-	-	-
Management[10]	-	-	-	-	-	-	-	-	-	172	565	552	104	1,393	35	44	42	32	30
Total	-	-	-	-	-	142	872	641	909	904	565	552	104	4,689	35	44	42	32	30
SCHOOL OF SCIENCE																			
Biology[7]	-	3	11	25	27	49	57	129	74	116	16	-	-	507	-	-	-	-	-
Undesignated	-	-	-	-	-	-	-	-	-	-	-	346	97	443	35	36	34	30	33
Chemistry	2	27	80	154	151	111	141	166	232	207	307	484	126	2,188	62	34	47	40	39
Earth and Planetary Sciences[8]	-	-	-	8	6	3	36	22	32	141	109	223	41	621	23	19	14	16	11
Undesignated	-	-	-	-	-	-	-	-	-	-	7	20	-	27	-	-	-	-	-
Food Technology and Biochemical Engineering	-	-	-	-	-	-	-	-	35	62	11	-	-	108	-	-	-	-	-
General Science or General Course	2	11	17	49	20	26	17	73	58	62	-	-	-	335	-	-	-	-	-
Interdisciplinary Science-Undesignated	-	-	-	-	-	-	-	-	-	-	-	81	7	88	9	6	1	5	1
Life Sciences[7]	-	-	-	-	-	-	-	-	-	-	291	886	155	1,332	72	87	54	57	44
Mathematics	-	-	-	-	-	-	19	48	72	220	831	867	161	2,218	59	45	48	57	56
Meteorology	-	-	-	-	-	-	-	-	56	38	-	-	-	94	-	-	-	-	-
Physics	-	5	6	24	19	21	49	170	306	617	1,079	937	221	3,454	91	72	78	91	52
Total	4	46	114	260	223	210	319	608	865	1,463	2,651	3,844	808	11,415	351	299	276	296	236
GRAND TOTAL	29	226	507	1,579	2,257	2,963	5,410	4,515	6,626	7,535	8,011	10,611	3,284	53,553	1,182	1,124	1,082	1,153	1,049

*Includes only February and May degrees
+Two received the degree in Naval Architecture, Course XIII-B, In 1916 and three in 1917
1 See also Table XI
2 Prior to 1923 degrees were awarded in Architecture
3 Prior to 1909 this course was designated as option 3 (Electrochemistry) or Physics
4 Prior to 1938 these degrees were included in Mining Engineering and Metallurgy; changed from Metallurgy to Metallurgy and Materials Science, January 1968; changed to Materials Science and Engineering 1975
5 Prior to 1958 these degrees were included in General Engineering and General Science or General Course
6 Changed to Sloan School of Management 1963
7 Changed to Life Sciences beginning January 1962
8 Changed from Geology and Geophyics to Earth Sciences in February 1961, changed from Earth Sciences to Earth and Planetary Sciences in February 1970
9 Prior to September 1965, these degrees were included in Economics, Politics and Engineering or Science
10 Prior to 1959, Business and Engineering Administration, changed from Industrial Management to Management in February 1967
11 Prior to 1960 Aeronautical Engineering

TABLE X NUMBER OF DEGREES OF MASTER OF SCIENCE AWARDED

	Total by decade												Calendar year since 1979 (included in decade total)				
	1886-90	1891-1900	1901-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1979	1980	1981	1982	1983*
SCHOOL OF ARCHITECTURE AND PLANNING[1]																	
Architecture	-	8	45	31	-	-	-	-	-	-	-	84	-	-	-	-	-
Architecture Studies	-	-	-	-	-	-	-	-	-	1	72	73	-	1	14	26	32
Architectural Engineering[2]	-	-	-	-	9	10	-	-	-	-	-	19	-	-	-	-	-
Visual Studies	-	-	-	-	-	-	-	-	-	22	42	64	12	10	13	15	14
Total	-	8	45	31	9	10	-	-	-	23	114	240	12	11	27	41	46
SCHOOL OF ENGINEERING																	
Aeronautics and Astronautics[11]	-	-	-	17	59	76	307	375	645	404	162	2,045	36	31	50	59	53
Building Engineering and Construction	-	-	-	-	-	-	21	66	21	-	-	108	-	-	-	-	-
Ceramics	-	-	-	-	-	3	3	13	20	31	16	86	3	1	4	9	3
Chemical Engineering	-	3	2	18	69	152	275	467	398	280	86	1,750	43	26	32	33	21
Chemical Engineering Practice	-	-	-	-	245	284	241	256	102	285	90	1,503	28	29	26	42	22
Civil Engineering	-	1	4	27	53	179	194	350	548	738	196	2,290	91	85	79	79	38
Electrical Engineering and Computer Science (including VI-A)[12]	-	-	7	43	462	474	546	1,164	1,529	1,201	421	5,847	119	149	148	157	116
Electrochemical Engineering	-	-	-	4	16	8	-	-	-	-	-	28	-	-	-	-	-
Fuel and Gas Engineering	-	-	-	-	15	11	-	-	-	-	-	26	-	-	-	-	-
Materials Engineering	-	-	-	-	-	-	-	-	-	40	27	67	8	5	10	14	3
Materials Science	-	-	-	-	-	-	-	-	-	42	17	59	6	11	5	6	6
Mechanical Engineering	-	1	8	22	100	175	357	525	690	734	337	2,949	71	98	119	125	93
Metallurgy	-	-	-	-	8	36	92	230	205	104	35	710	6	11	10	15	10
Mining Engineering	-	-	-	9	8	16	-	-	-	-	-	33	-	-	-	-	-
Naval Architecture and Marine Engineering	-	-	2	1	5	20	60	165	281	233	51	814	24	20	23	15	13
Naval Construction and Engineering	-	-	39	48	101	89	206	-	-	-	-	483	-	-	-	-	-
Nuclear Engineering[3]	-	-	-	-	-	-	-	67	282	349	73	771	23	40	27	23	23
Ocean Engineering	-	-	-	-	-	-	-	-	3	157	58	222	17	15	15	25	18
Ocan Systems Management	-	-	-	-	-	-	-	-	-	3	31	34	-	3	7	18	6
Petroleum Engineering	-	-	-	-	-	5	-	-	-	-	-	5	-	-	-	-	-
Polymerics	-	-	-	-	-	-	-	-	-	16	15	31	2	7	5	6	4
Railroad Engineering	-	-	-	-	-	14	-	-	-	-	-	14	-	-	-	-	-
Sanitary Engineering	-	-	2	8	3	10	53	99	16	-	-	191	-	-	-	-	-
Shipping and Shipbuilding Management[13]	-	-	-	-	-	-	-	4	15	56	2	77	8	2	2	-	-
Technology and Policy	-	-	-	-	-	-	-	-	-	43	49	92	14	19	18	16	15
Textile Technology	-	-	-	-	-	1	31	34	20	11	-	97	-	1	-	-	-
Total	-	5	64	197	1,144	1,553	2,386	3,815	4,775	4,727	1,666	20,332	499	553	580	642	444

SCHOOL OF HUMANITIES AND SOCIAL SCIENCE																		
Economics[7]	-	-	-	-	-	-	-	-	19	22	3	44	2	1	-	2	1
Economics and Engineering or Science[10]	-	-	-	-	-	12	16	19	10	-	-	57	-	-	-	-	-
Linguistics	-	-	-	-	-	-	-	-	1	7	2	10	-	-	2	-	-
Philosophy	-	-	-	-	-	-	-	-	2	8	2	12	-	-	-	2	-
Political Science[7]	-	-	-	-	-	-	-	-	25	105	33	163	16	10	7	8	18
Psychology[4]	-	-	-	-	-	-	-	-	7	9	1	17	-	-	-	1	-
Total	-	-	-	-	-	12	16	19	64	151	41	303	18	11	9	13	19
SLOAN SCHOOL OF MANAGEMENT[5]																		
Management[8]	-	-	-	-	4	60	122	581	1,274	1,859	668	4,568	203	195	216	221	231
SCHOOL OF SCIENCE																		
Biochemical Engineering	-	-	-	-	-	-	-	-	17	31	15	63	1	6	4	6	5
Biochemistry	-	-	-	-	-	-	-	3	6	6	-	15	-	1	-	-	-
Biology	-	1	1	10	1	19	25	29	12	44	6	148	-	3	1	3	2
Biophysics	-	-	-	-	-	-	-	2	3	3	-	8	-	-	-	-	-
Chemistry	2	3	7	22	32	51	53	46	97	69	10	392	5	3	2	7	1
Earth and Planetary Sciences	-	-	-	-	-	-	-	-	7	89	15	111	11	6	8	6	1
Food Science and Technology	-	-	-	-	-	-	-	-	57	56	15	128	10	7	4	4	7
Food Technology	-	-	-	-	-	-	12	44	3	-	-	59	-	-	-	-	-
General Science	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Geology and Geophysics[9]	-	-	2	5	21	15	17	48	71	-	-	179	-	-	-	-	-
Interdisciplinary Science	-	-	-	-	-	-	-	-	-	30	15	45	9	2	7	7	1
Mathematics	-	-	-	2	9	25	45	96	73	66	18	334	9	7	7	6	5
Metabolism and Human Nutrition	-	-	-	-	-	-	-	-	-	-	9	9	-	-	1	3	5
Meteorology and Physical Oceanography[6]	-	-	-	-	-	35	99	118	87	83	16	438	11	4	4	6	6
Neural and Endocrine Regulation	-	-	-	-	-	-	-	-	-	6	4	10	-	2	1	2	1
Nutrition	-	-	-	-	-	-	-	-	23	-	-	23	-	-	-	-	-
Nutritional Biochemistry and Metabolism	-	-	-	-	-	-	-	7	25	96	22	150	10	9	11	6	5
Oceanography	-	-	-	-	-	-	-	-	28	23	3	54	3	3	2	1	-
Physics	-	3	2	2	16	40	50	121	138	139	30	541	15	11	7	14	9
Toxicology	-	-	-	-	-	-	-	-	-	13	4	17	4	-	1	2	1
Total	2	8	12	41	79	185	301	514	647	754	182	2,725	88	64	60	73	49
Management of Technology	-	-	-	-	-	-	-	-	-	-	14	14	-	-	-	5	9
Operations Research	-	-	-	-	-	-	-	-	2	77	15	94	4	9	4	8	3
Transportaion	-	-	-	-	-	-	-	-	-	4	48	52	-	4	10	25	13
Without Course Specification	-	-	-	5	308	263	123	357	299	385	92	1,832	41	39	25	36	31
Grand Total	2	21	121	274	1,544	2,083	2,948	5,286	7,061	7,980	2,840	30,160	865	886	931	1,062	845

*Includes only February and May degrees
[1]See Table XI
[2]Prior to 1923 degrees were awarded in Architecture
[3]Prior to 1959 included in Chemical Engineering
[4]Prior to September 1964 included in Economice, Politics and Engineering or Science
[5]Considered Engineering until 1950
[6]Considered Engineering until 1956; prior to 1981 Meteorology
[7]Prior to September 1965 included in Economics, Politics and Engineering or Science
[8]Prior to Februáry 1967 Industrial Management
[9]Changed to Earth and Planetatry Sciences beginning February 1970
[10]Includes six degrees in Political Science awarded 1965
[11]Prior to 1960 Aeronautical Engineering
[12]Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
[13]Changed from Shipping and Shipbuilding Management to Ocean Systems Management 1980

TABLE XI NUMBER OF DEGREES OF BACHELOR AND MASTER IN ARCHITECTURE AND BACHELOR AND MASTER IN CITY PLANNING

	Total by decade								Calendar Year since 1979 (included in decade total)				
	1921-30	1931-40	1941-50	1951-60	1961-70	1971-1980	1981-	Grand Total	1979	1980	1981	1982	1983*
Bachelor in Architecture[2]	-	146	126	257	188	5	-	722	-	-	-	-	-
Bachelor in City Planning[1]	-	14	13	4	-	-	-	31	-	-	-	-	-
Master in Architecture[3]	63	81	78	191	214	21	-	648	-	-	-	-	-
Master in City Planning	-	18	82	114	152	317	127	810	49	35	41	52	34
Master of Architecture	-	-	-	-	23	279	96	398	37	27	26	47	23
Master of Architecture in Advanced Studies	-	-	-	-	-	193	11	204	24	25	9	2	-
Grand Total	63	259	299	566	577	815	234	2,813	110	87	76	101	57

*Includes only February and May degrees

[1]From 1935 to 1944, Bachelor of Architecture in City Planning

[2]Degree of Bachelor in Architecture changed to degree of Master of Architecture 1972

[3]Degree of Master of Architecture changed to degree of Master of Architecture in Advanced Studies in June 1972

TABLE XII NUMBER OF DEGREES OF ENGINEER AWARDED

	Total by decade					Calendar year since 1979 (included in decade total)				
	1949-60	1961-70	1971-80	1981-	Grand Total	1979	1980	1981	1982	1983*
Building Engineer[3]	5	2	-	-	7	-	-	-	-	-
Chemical Engineer	17	31	65	12	125	3	8	6	2	4
Civil Engineer	21	78	64	17	180	4	2	8	6	3
Electrical Engineer	132	444	381	80	1,037	24	25	28	29	23
Engineer in Aeronautics and Astronautics[1]	35	58	24	4	121	2	-	3	-	1
Environmental Engineer	-	-	12	1	13	-	1	1	-	-
Marine Mechanical Engineer	7	2	1	-	10	-	-	-	-	-
Materials Engineer	-	7	8	1	16	-	-	-	-	1
Mechanical Engineer	102	166	100	12	380	7	3	5	3	4
Metallurgical Engineer[2]	24	18	7	-	49	-	-	-	-	-
Meteoroligist[2]	2	-	-	-	2	-	-	-	-	-
Naval Architect	11	21	17	-	49	-	-	-	-	-
Naval Engineer	334	246	20	-	600	-	-	-	-	-
Nuclear Engineer	-	37	74	12	123	7	9	5	4	3
Ocean Engineer	-	4	199	54	257	18	18	19	18	17
Sanitary Engineer[3]	9	3	-	-	12	-	-	-	-	-
Total	699	1,117	972	193	2,981	65	66	75	62	56
Awarded jointly with Woods Hole Oceanographic Institution										
Electrical Engineer	-	-	1	-	1	1	-	-	-	-
Civil Engineer	-	-	-	1	1	-	-	-	-	1
Ocean Engineer	-	-	15	3	18	3	1	1	2	-
Grand Total	699	1,117	988	197	3,001	69	67	76	64	57

*Includes only February and May degrees

[1]Prior to 1969 Aeronautical Engineer

[2]Degree discontinued after 1955

[3]Degree discontinued after 1964

TABLE XIII NUMBER OF DEGREES OF DOCTOR OF PHILOSOPHY AWARDED

	Total by decade										Calendar year since 1979 (included in decade total)				
	1907-10	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1979	1980	1981	1982	1983*
SCHOOL OF ARCHITECTURE AND PLANNING															
Architecture	-	-	-	-	-	-	-	4	5	9	1	1	2	1	2
Urban Studies and Planning[6]	-	-	-	-	-	-	24	72	30	126	12	10	14	8	8
Total	-	-	-	-	-	-	24	76	35	135	13	11	16	9	10
SCHOOL OF ENGINEERING															
Aeronautics and Astronautics[7]	-	-	-	-	-	6	57	100	32	195	9	11	14	5	13
Chemical Engineering	-	-	-	-	-	-	31	51	15	97	7	8	2	6	7
Civil Engineering	-	-	-	-	-	1	72	142	40	255	13	14	18	14	8
Electrical Engineering and Computer Science[9]	-	-	-	-	1	9	248	371	89	718	42	36	38	34	17
Materials Science and Engineering[3]	-	-	-	-	-	6	103	127	43	279	6	11	10	19	14
Mechanical Engineering	-	-	-	-	-	4	95	140	56	295	16	12	19	19	18
Nuclear Engineering	-	-	-	-	-	5	90	111	39	245	11	15	14	15	10
Ocean Engineering[8]	-	-	-	-	-	-	15	42	18	75	6	3	7	5	6
Sanitary Engineering	-	-	-	-	-	2	3	-	-	5	-	-	-	-	-
Total	-	-	-	-	1	33	714	1,084	332	2,164	110	110	122	117	93
SCHOOL OF HUMANITIES AND SOCIAL SCIENCE															
Economics[1]	-	-	-	-	19	96	195	229	67	606	28	26	24	25	18
Group Psychology	-	-	-	-	8	1	-	-	-	9	-	-	-	-	-
Linguistics	-	-	-	-	-	-	35	68	15	118	3	10	3	7	5
Linguistics and Philosophy	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-
Philosophy	-	-	-	-	-	-	8	24	11	43	1	2	6	2	3
Political Science	-	-	-	-	-	-	71	117	39	227	11	11	11	14	14
Psychology	-	-	-	-	-	3+	24	49	13	89	2	6	7	4	2
Total	-	-	-	-	27	100	333	487	146	1,093	45	55	51	53	42

SLOAN SCHOOL OF MANAGEMENT															
Management[2]	-	-	-	-	-	-	89	120	30	239	18	5	8	14	8
SCHOOL OF SCIENCE															
Biology	-	1	10	17	21	38	105	167	41	400	17	14	12	14	15
Chemistry	7	19	59	146	180	342	427	406	105	1,691	37	32	39	37	29
Earth and Planetary Sciences[4]	1	7	10	22	20	71	84	99	37	351	11	8	17	12	8
Mathematics	-	-	6	25	35	70	211	231	52	630	19	20	21	17	14
Meteorology and Physical Oceanography[10]	-	-	-	-	-	14	45	35	15	109	2	3	3	7	5
Nutrition and Food Science	-	-	-	-	4	28	66	156	55	309	23	23	18	20	17
Oceanography[5]	-	-	-	-	-	-	11	-	-	11	-	-	-	-	-
Physics	-	2	6	48	159	283	390	383	106	1,377	39	27	34	38	34
Total	8	29	91	258	419	846	1,339	1,477	411	4,878	148	127	144	145	122
Health Sciences and Technology	-	-	-	-	-	-	-	-	4	4	-	-	1	-	3
Awarded jointly with Woods Hole Oceanographic Institution															
Biology	-	-	-	-	-	-	-	14	3	17	1	4	2	1	-
Civil Engineering	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-
Earth and Planetary Sciences	-	-	-	-	-	-	4	47	14	65	3	13	3	6	5
Electrical Engineering and Computer Science	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Meteorology and Physical Oceanography[10]	-	-	-	-	-	-	1	15	7	23	1	1	2	4	1
Ocean Engineering	-	-	-	-	-	-	-	6	-	6	-	-	-	-	
Total	-	-	-	-	-	-	5	83	25	113	5	18	7	12	6
Grand Total	8	29	91	258	447	979	2,504	3,327	983	8,626	339	326	349	350	284

*Includes only February and May degrees
+Previously included in Industrial Economics
[1]Changed from Industrial Economics to Economics 1966
[2]Changed from Industrial Management to Management 1967
[3]Includes Ceramics; Metallurgy and Materials Science changed to Material Science and Engineering 1975
[4]Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
[5]Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology
[6]Changed from City and Regional Planning to Urban Studies and Planning 1969
[7]Prior to 1960 Aeronautical Engineering
[8]Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1971
[9]Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
[10]Changed from Meteorology to Meteorolgy and Physical Oceanography 1981

TABLE XIV NUMBER OF DEGREES OF DOCTOR OF SCIENCE AWARDED

	Total by decade									Calendar year since 1979 (included in decade total)				
	1911-20	1921-30	1931-40	1941-50	1951-60	1961-70	1971-80	1981-	Grand Total	1979	1980	1981	1982	1983*
SCHOOL OF ENGINEERING														
Aeronautics and Astronautics[1]	2	4	5	18	31	76	51	9	196	5	6	4	1	4
Chemical Engineering	-	23	78	114	117	151	77	31	591	7	5	13	12	6
Civil Engineering	-	2	12	23	46	75	45	12	215	1	6	2	9	1
Electrical Engineering and Computer Science[5]	3	12	30	34	141	124	68	21	433	8	6	9	7	5
Electrochemical Engineering	-	1	1	-	-	-	-	-	2	-	-	-	-	-
Materials Science and Engineering[6]	-	14	32	86	194	201	102	29	658	12	10	8	13	8
Mechanical Engineering	-	4	13	35	125	145	83	14	419	7	8	3	4	7
Mineral Engineering	1	-	4	-	-	-	-	-	5	-	-	-	-	-
Nuclear Engineering	-	-	-	-	9	55	55	9	128	4	7	2	6	1
Ocean Engineering[4]	-	1	-	-	2	6	12	1	22	1	1	-	1	-
Petroleum Engineering	-	-	1	-	-	-	-	-	1	-	-	-	-	-
Sanitary Engineering	-	-	2	3	18	2	-	-	25	-	-	-	-	-
Total	6	61	178	313	683	835	493	126	2,695	45	49	41	53	32
SCHOOL OF SCIENCE														
Chemistry	-	2	5	4	3	1	2	-	17	-	-	-	-	-
Earth and Planetary Sciences[2]	1	2	4	5	2	3	7	2	26	-	-	1	-	1
Mathematics	-	2	3	-	1	1	2	1	10	-	-	1	-	-
Meteorology and Physical Oceanography[7]	-	-	6	25	17	6	10	2	66	1	1	1	-	1
Nutrition and Food Science	-	-	-	3	10	17	21	7	58	1	1	2	2	3
Oceanography[3]	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Physics	-	5	18	14	7	7	17	5	73	2	1	-	4	1
Total	1	11	36	51	40	36	59	17	251	4	3	5	6	6
Awarded jointly with Woods Hole Oceanographic Institution														
Earth and Planetary Sciences	-	-	-	-	-	-	1	2	3	-	-	1	-	1
Electrical Engineering and Computer Science	-	-	-	-	-	-	-	1	1	-	-	-	-	1
Materials Science and Engineering	-	-	-	-	-	-	-	1	1	-	-	1	-	-
Meteorology and Physical Oceanography[7]	-	-	-	-	-	-	7	-	7	1	1	-	-	-
Ocean Engineering	-	-	-	-	-	-	-	1	1	-	-	-	-	1
Total	-	-	-	-	-	-	8	5	13	1	1	2	-	3
Grand Total	7	72	214	364	723	871	560	148	2,959	50	53	48	59	41

*Includes only February and May degrees
[1]Prior to 1960 Aeronautical Engineering
[2]Changed from Geology and Geophysics to Earth and Planetary Sciences 1970
[3]Beginning 1967-68 included in Earth and Planetary Sciences or Meteorology and Physical Oceanography
[4]Changed from Naval Architecture and Marine Engineering to Ocean Engineering 1970
[5]Changed from Electrical Engineering to Electrical Engineering and Computer Science 1975
[6]Changed from Metallurgy and Materials Sciencce to Materials Science and Engineering 1975
[7]Changed from Meteorology to Meteorology and Physical Oceanography 1981

TABLE XV SUMMARY OF DEGREES AWARDED
(1868-1983)

Bachelor in Architecture (discontinued 1972)	722
Bachelor in City Planning (discontinued 1954)	31
Bachelor of Science	53,553
Master in Architecture (discontinued 1972)	648
Master in City Planning	810
Master in Public Health (discontinued 1944)*	104
Master of Architecture	398
Master of Architecture in Advanced Studies	204
Master of Science	30,160
Advanced Engineering	2,981
Advanced Engineering awarded with Woods Hole Oceanographic Institution	20
Doctor of Engineering (discontinued 1918)*	4
Doctor of Philosophy	8,513
Doctor of Philosophy awarded jointly with Woods Hole Oceanographic Institution	113
Doctor of Public Health (discontinued 1944)*	9
Doctor of Science	2,946
Doctor of Science awarded jointly with Woods Hole Oceanographic Institution	13
	101,229

*See 1959 Report of the Registrar for details

WARREN D. WELLS

Vice President in the Office of the President

Last year I prefaced the annual reports of the departments for which I am responsible with a description of our strategic planning process. I said, "In the next two years the strategic management system we have been developing will be put to a serious test as we proceed to retrench financially at a time when there is growing demand for support and for services to people throughout MIT."

I believe 1982-83 has been at once a painful, productive, and promising year for MIT people everywhere, particularly for members of the administrative and support staff. It was painful because several valued colleagues were laid off. Departments and offices throughout MIT made every effort to achieve staff reductions by attrition whenever possible. Yet, during the year, 124 individual members of the research, administrative, and support staffs were given layoff notice. Less than one-third of them were able to stay at MIT in other jobs. In the MIT Press, for instance, there was a reduction of personnel by 15 percent, which required discontinuing some publishing programs and realigning of responsibilities throughout the organization.

Unfortunately, the necessary budget cutting could not be accomplished in one year. We had to set further reduction goals for FY 1984 and 1985 last spring, making a three-year commitment for savings which, in the areas for which I am responsible, exceed 15 percent of the total budget.

Managers and staff members worked together and successfully laid out the required plans. But, as we try to carry out these plans, we find growing resistance in the community to any curtailment of services; and we find rising tensions and a feeling of overwork reflected among colleagues who feel that they are asked to do more with less. A few staff members express dismay at the relentless pressure to cut budgets. One of them said to me recently that, although the job is getting done, "the fun has come out of what we do."

This is a serious problem. In the fast-paced, pressured environment of MIT, high morale is a desirable if not a necessary cultural ingredient. In my 23 years here, I have taken it for granted as a staff member, and I have come to expect it as a manager. How to maintain and restore enthusiasm for work in the face of layoffs and retrenchment is a major challenge for all of us.

The challenge lies in turning adverse circumstances into opportunities for growth, for increased responsibilities, shared by a smaller staff, and for closer cooperation and teamwork. These healthy traits cannot coexist with feelings of isolation, divisiveness, and territoriality which also spawn from adversity. Happily, there are a few positive signs at year-end. To use the same department mentioned above as an example, the MIT Press has managed to turn the corner, reduce its deficit by two-thirds of what was expected, and emerge with a stronger, more focused, and tighter publishing plan for the current year. It may be too soon to be certain, but I believe that these early signs of recovery will make the difference both in the financial bottom line and in the morale of the people involved.

This pattern can be generalized: a firmer hold on the agenda; a clearer and more realistic view of priorities; a lean, hardworking staff; and a persistent commitment to providing services of high quality -- these are the unmistakable signals of greater productivity in our business. In this respect, the past year was indeed a productive year for all of the departments that report to me. Recognizing the value of positive reinforcement, especially in these difficult times, we tried to strengthen our reward system this spring by urging supervisors to make careful and discriminating reviews of staff performance at all levels. The recognition of high quality work, expressed in financial and in other less tangible ways, is the key to maintaining a healthy working environment. Demanding greater contributions and rewarding those who respond always pays off. We must put more of our energies into setting clear standards and into performance appraisals with full opportunity for communication; we must single out and reward visibly those who excel; we must give special recognition to those who understand, welcome, and encourage diversity; and we must continue to devote time and resources to mentoring -- to help those who carry the load of the work advance their own careers and develop their skills and interests. Productivity, in the long term, is measured both by the amount of work accomplished, and by the personal and professional growth experienced by those who do the work.

The third adjective I used to characterize this year was "promising," and this relates to the evidence of resolve and commitment of the Institute to long-range planning. As this report is written, in the summer of 1983, I am happy to observe that every part of the academic and administrative structure of MIT is seriously engaged in five-year planning. The Provost has convened an Institute Planning Group whose purpose is to receive plans and to oversee their integration into a central MIT plan; to encourage, urge, and require planning in all MIT departments; and to develop agenda for major policy issues which cut across departmental lines, and which will be dealt with by ad hoc task forces working on a specified timetable. On May 5 of this year, the President called a two-day meeting of the Executive Committee of the Corporation, which he chairs, in order "to share with the key Trustees of the Institute our current concerns and future aspirations for MIT." Such a meeting was unprecedented in my experience of the past 13 years as Secretary of the Executive Committee.

This flurry of planning activity throughout the campus is indeed a gratifying sign that holds promise for the future of MIT. Planning does not guarantee good management, however, unless strategic considerations become visible and integral to all of our important decisions and to our daily actions on the job. And even when that near-perfect state of strategic management is achieved, there will still be a higher challenge: to make sure that preoccupations with planning, management, and performance will not detract from our ability to bolster our professional work with personal judgment and caring, and, yes, to laugh once in a while.

CONSTANTINE B. SIMONIDES

Affirmative Action/Equal Opportunity

This year has been one of painful transition for the nation. Several unsettling, major trends emerged:

1. marked decline in governmental support for education, research, and human services

2. continued high unemployment rates, with Black unemployment (especially among youth) reaching a post-depression high

3. reduced support for Affirmative Action/Equal Opportunity regulations at the Federal level

4. retarded growth of the economy

The MIT community has felt the impact of these trends in many ways and at every level. For example, students and parents have had and continue to have difficulty financing education; faculty and researchers have begun to shift fund-raising efforts to the private sector for support of major research projects; and central administration has announced major cut-backs in personnel and expenses, so as to reduce an operating deficit.

Despite these developments, MIT has continued slow but steady movement forward in the Equal Opportunity/Affirmative Action area. First, we have reaffirmed our commitment to a diverse community in the face of retrenchment. Second, we successfully completed a Department of Labor Compliance Review in February of 1983. Third, we have strengthened our outreach to the minority communities of greater Boston through continued particpation in the Black Achievers Program of the YMCA and participation on the Board of the Cass Branch of the Boston YWCA. Fourth, we have initiated and supported training efforts for the community at large on equal opportunity and personnel issues generally.

We recognize the need to increase MIT's diversity and there is considerable work to be done in this area. Presently, our work force is 12% minority (five percent Black-American, five percent Asian-American, and two percent Hispanic), 88% non-minority, 37% female and 63% male. Of particular concern is the small number of Black and Hispanic faculty and administrative staff.

Encouraging are three initiatives guided by the Deans of the School of Science, Humanities and Social Science, and Engineering. Central to these initiatives is an Affirmative Action Committee in each School which has the following strengths:

1. the active involvement of the Dean, who serves as Chair

2. strong staff support in the Office of the Dean

3. a diverse membership comprised of people with proven track records and linkages to minority and women's professional networks

4. adequate provision for monitoring

We see this "experiment" in decentralization as a positive step -- hopefully one which produces better results.

In summary, the 1982-83 year has been one of challenge and economic difficulty for MIT and the nation. We have sought to meet the challenge, to face our fiscal constraints, to maintain a humane workplace, and to increase our diversity.

PATRICIA BELL-SCOTT

Campus Information Services

The Campus Information Services -- consisting of the Communications Office, the Office of Design Services, and the Information Center -- continued its efforts to foster a shared sense of purpose and understanding of issues and activities within the MIT community and to communicate with visitors and the more distant public in ways which reflect credit on and generate interest in MIT. Because of the Institute's financial stringencies, the Services will continue to seek ways to meet these priorities through new ways of organizing our own activities or working with other departments, rather than expanding our operation to meet the growing demands for information and service.

KATHRYN W. LOMBARDI

Communications Office

During 1982-83 the Communications Office produced its nine annual publications and provided editorial and production assistance to administrative and academic departments at MIT.

Several improvements were made in the production and distribution of *Courses and Degree Programs*. We shortened the 1982-83 book 64 pages by eliminating the administrative listings section and reducing the size of body type in chapters one through six. The administrative listings were moved to the staff telephone *Directory*, which is a more appropriate place for information used primarily by MIT employees. Since the print run of the catalogue is 65,000 copies, the elimination of 64 pages per book translates into a total reduction of 4,160,000 pages. The result of this effort represented not only a dollar savings to the Institute but also a more manageable, less bulky book.

This year, we began a program to monitor more carefully the distribution of the catalogue, both to cut down on waste and to determine the breakdown of our audience. We informed current MIT students that they would receive only one copy of the book per year, and prospective students and other visitors were asked to come to the Communications Office if they wanted a catalogue. This gave us more control over the distribution and important information on the makeup of our audience. Our efforts have paid off: catalogues are still available at the end of June, while in past years the supply had been depleted by the end of April.

During the year, Janet Snover, Communications Manager, was a member of a task force set up to review and improve several sections of the catalogue. Organized by Professor Felix Villars, Chairman of the Faculty, the group included the chairmen of the Committee on Curricula (Professor Alvin Drake) and the Committee on Graduate School Policy's Subcommittee on Subjects (Professor George Koster), the Associate Registrar (Ronald Smith), the Secretary of the Committee on Educational Policy (David Wiley), and the Administrative Staff Assistant to Dr. Wiley and Ms. Snover (Barbara Engel). The group recommended a number of changes to improve the subject descriptions chapter of the book. These changes, which will be made in the 1983-84 edition, included the following:

- The complete description of a "J" subject (jointly taught by two or more departments) will appear only once in the chapter. A reference to the location of the full description will appear in each participating department.

- Subjects which will not be offered either in the catalogue year or the following year will not be listed in the book. The issue here is truth in advertising.

- The length of the text of subject descriptions will be limited to 13 lines.

- The band of white space at the top of pages in this chapter will be used for text, while still retaining the book's grid system.

In addition, significant improvements were made in the organization and readability of the "Interdepartmental Study and Research" chapter of the book. We expect that the changes in these two chapters will contribute toward a more informative and manageable book. We have completed production on much of the 1983-84 edition and anticipate that it will be 128 pages shorter than the 1982-83 book. The task force will continue to work on the catalogue next year, concentrating on the "Departmental Programs and Requirements chapter of the book.

The Communications Office provided editorial and production assistance on a variety of projects originating in academic and administrative areas. We took on editorial assignments, as time allowed, between our annual publications and gave advice on production issues such as scheduling, printing sources and procedures, and photo selection. A major editorial project during 1982-83 was work with the Centennial Study Committee of the Department of Electrical Engineering and Computer Science on their report entitled "Lifelong Cooperative Education."

In the fall, Ms. Snover repeated the Publications Production Workshop as part of MIT's Personnel Development Program. Details about the Workshop are given in last year's annual report.

Outside of MIT, Ms. Snover chaired the Awards Committee of the Council for the Advancement and Support of Education for District One. In April, she spoke on "Professional School Recruitment Publications" at the Boston meeting of the American Association of Collegiate Registrars and Admissions Officers.

JANET L. SNOVER

Design Services

The Office of Design Services, under the direction of Jacqueline Casey, continues to support the communications efforts of MIT by designing and managing the production of publications for departments and offices throughout the Institute. Among the areas receiving major assistance from the office during the past year were the Admissions Office; the Corporation; the Committee on the Visual Arts; Resource Development; a variety of programs in the School of Architecture and Planning, the School of Engineering, and the Sloan School of Management; the Special Summer Programs; and a wide range of special events and conferences coordinated by the Information Center. As in the past, the Office provided major design and production support for the communications program of the Alumni Association, including design direction for *Technology Review*. Overall, the Office undertook 354 graphic design and publishing projects during 1982-83.

The Office was highlighted in the recently published "A History of Graphic Design" by Philip Meggs. Cited in the chapter titled "The International Typographic Style in America," the author says "A sustained level of quality and imagination has been sustained by the graphic design group at the Massachusetts Institute of Technology."

Professional recognition was accorded to the design efforts of Nancy Cahners, Ms. Casey, Ralph Coburn, and Betsy Hacker. Their work was included in the New York Type Directors Show, Print's Regional Design Annual 1982, and the AIGA: Graphic Design 3 Annual. Ms. Casey's work was included in the AIGA Just Type Show, and Ms. Cahners was exhibited in the Boston Art Directors Show.

Ms. Casey judged several national design competitions. Among them were the Dallas Communications Show, the Philadelphia Chapter of the AIGA, and the first national Student Poster Competition at Coker College in South Carolina. She lectured at SUNY in New York and North Carolina State University at Raleigh. Her posters were included in an international exhibition of AGI members at Place Ville Marie in Montreal, and the Lahti Poster Biennale in Finland. Ms. Casey was featured in the book "Top Graphic Design" published in Zurich. She was one of twenty-five designers chosen worldwide. Her work was also included in the Viking Press book "Advertising: Reflections of a Century."

JACQUELINE S. CASEY

Information Center

Of all the many public relations operations at MIT, the Information Center serves as the central area in the Institute for general information on Institute events, programs and activities. This service is provided in three major areas: information dissemination; coordination of major Institute events and conferences; and support for international faculty, staff, and visitors.

Although the year began without any major administrative changes in operations, the Special Events Section moved to Room 7-111 in the lobby of Building 7, providing a much needed central location for this operation. Because of insufficient space, this move necessitated the subsequent move of the Center's administrator, Lillian Whelpley, to an office in Building 4.

The only personnel change was the departure of Constance Cunningham from the International Visitors Section. She has been succeeded by Virginia Silverman.

Public Relations and Information Services. The staff in the Center is charged with gathering and providing information to members of the MIT community as well as to visitors; compiling information for the MIT planning calendar; managing the guided tours of the campus; updating the Institute map and visitors guide; maintaining and authorizing the use of official Institute mailing lists; identifying and forwarding Institute

mail that has been addressed generally to MIT; and maintaining, publishing, and distributing a comprehensive "catalogue" of Institute committees.

During the past year, the following volume in printed materials was distributed from the Center:

Bulletins	1,784
MIT maps and guides	23,061
Other publications	19,849

A popular public relations function of the Center is the student-guided tours of the Institute, which are given primarily for prospective students and their families. The following is a tally of the numbers of visitors who took tours during this past year:

Prospective students	2,767
International students	982
General visitors	3,701
Total	7,450
Visitors on special tours	912
Visitors on general tours	6,538
Total	7,450

Following the Information Center's tradition of hiring MIT students to conduct guided tours of the Campus, we were again fortunate in having 27 enthusiastic and motivated guides, trained and supervised by head guide Shih-Chii Liu, '83. Special thanks to Robert Minnichelli, '84, and Christina Panagakos, '84, for their help both in guiding the tours and in working in the Information Center this past summer.

International Visitors Office. The International Visitors Office in the Information Center continued its traditional activities, serving the needs of international visitors, faculty, and staff on campus, and became involved in a number of new projects during the 1982-83 academic year.

New projects included active involvement in the International Advisory Working Group convened by Dr. Louis Menand; closer contact with the Boston Fulbright coordinator; Ms. Lyons' responsibilities as Regional Chair of the National Association for Foreign Student Affairs (NAFSA); efforts to inform legislators about the potential impact of the proposed immigration reform legislation (the Simpson-Mazzoli bill) on colleges and universities; and participation in the Personnel Office's Administrative Procedures program. Staff support by Ms. Lyons to the Committee on International Institutional Commitments continued, with the increased visibility of the Committee generating 66 proposals for review.

Ms. Lyons was awarded a Fulbright grant to travel to Germany during the spring with a group of university administrators for discussions on the educational, cultural, and political issues involved in the present and future development of US-German student exchanges. It was exciting and rewarding both as a professional and a personal experience.

Intense budget scrutiny made staff more aware of and concerned about the way the office functions and what it handles. At the same time, we are aware that outside forces, such as changing regulations and laws, or federal government decisions to increase the number of foreign visitors invited have a significant effect on the section's workload. We expect to continue to seek creative solutions to an increasing amount of paperwork and administrative detail.

Special Events and Conferences. During the past year, this section of the Information Center provided assistance in the logistical coordination of nine major conferences held on Campus: The International Federation of the Organic Agriculture Movements Conference; The American Libraries Association Collection Management and Development Institute Meeting; The Noise Control Engineering Conference (NOISE-CON '83); The Physicians for Social Responsibility Meeting; The Conference on Photovoltaics - From Research to Reality; The Tenth International Optical Computing Conference; The National Science Foundation Meeting on Optical Communication Systems; The Fifth Conference on the Physics of the Jovian and Saturnian Magnetospheres; and The Meeting of the Society of Industrial and Applied Mathematics.

Planning has continued for several major conferences scheduled for 1984.

During the fall semester of 1982 and the spring semester of 1983, the Special Events Office made arrangements for 50 presentations by companies visiting the campus in association with the Office of Career Services and Preprofessional Advising.

In addition to overseeing the activities of the Center, the Director was directly responsible for coordinating many dedications and symposia, as well as serving as Executive Secretary of the Commencement Committee. Despite heavy rain and cold, Commencement was, once again, a popular annual event. The distinguished speaker was Helmut Schmidt, immediate past chancellor of the Federal Republic of Germany.

This report would not be complete without the recognition of the support of all the members of the office staff. Virginia Lyons, Terri Priest, Virginia Silverman, and Lillian Whelpley handled visa applications, questions, and problems for the 913 international faculty and staff appointed at MIT, made individual arrangements for 1,480 foreign visitors, arranged for representation by MIT at 23 other universities' ceremonial events, provided information about MIT and government requirements to newly arrived international staff, filed labor certifications for 23 individuals, and acted as the liaison with fellowship agencies wishing to place foreign scholars at MIT. Their knowledge of MIT, the outside agencies they work with, ability to work together, and to assume more responsibility are invaluable assets to the office and the Institute. In addition, Terri Priest's skillful organizational ability allows her to handle many public relations functions in the Center, and Lillian Whelpley, who in addition to her International Visitors office duties provides invaluable staff support as Administrator in the Center. Kathleen Barrett untiringly and pleasantly serves the community and the public at large with a sense of duty and caring; Donald Ferland continues to work effectively and with a sense of humor, particularly during stressful weeks; Gayle Fitzgerald continues to enhance the reputation of MIT as the logistical coordinator for on-campus meetings and conferences; and Sarah Clere provides invaluable staff support for the many conferences held at MIT. The Director would like to extend appreciation to each and every one of these people for their extraordinary support to the Center, the visitors, and the MIT community.

MARY L. MORRISSEY

Dean for Student Affairs

INTRODUCTION

During the 1982-83 academic year, the Office of the Dean for Student Affairs (ODSA) continued to be involved in activities designed to support and complement the Institute's academic program. Staff within the Undergraduate Academic Support, Student Assistance Services, and the Residence and Campus Activities sections of the Office were engaged in efforts to: assist freshmen in the transition from a dependent environment to an independent one, support the personal growth and development of students, promote a healthy living environment, and assist in the development of good citizens.

While many of these efforts are described in detail by the various sections in the report which follows, our core programs in support of undergraduate education were freshman advising and orientation, the Faculty and Graduate Resident Program, personal advising and counseling, and studies and services to the Committee on Educational Policy.

Support was also provided to a number of groups including:

1) The Independent Living Groups, Nightline (a peer counseling group), and other special student groups such as international, graduate, women, minority, transfer, gay, and handicapped students.

2) Student government groups such as the Undergraduate Association, the Graduate Student Council, the Interfraternity Conference, and House governments.

3) The Committee on Academic Performance, the Committee on Student Affairs, the Committee on Discipline, the Committee on Foreign Scholarships, the Advisory Committee on Women Students' Interests, the Dining Advisory Board, and the Alumni Interfraternity Conference.

4) Student activity groups and efforts such as the Activities Development Board, the Student Art Association, the Hobby Shop, the Awards Convocation, and the Student Committee on Educational Policy.

In addition, programs or publications focusing on quality of life issues such as study skills, human relations, harassment, sexuality, and personal relationships were developed.

Other responsibilities included the Undergraduate Seminar Program, dormitory assignments and billings for the undergraduate system and for Ashdown and Green Halls, the scheduling and managing of student activity space in the Stratton Student Center and Walker Memorial, and long-range planning for housing.

One highlight of the year was the visit to campus by the Visiting Committee on Student Affairs in November, 1982 and the prior preparation by students and staff of a 135-page report for the Committee on the state of student activities at the Institute. More details on the Committee's recommendations and on follow-up efforts are described in the report of the Residence and Campus Activities Section.

A second major development was ODSA's successful, though strained, operation with a budget that was cut by five percent over the previous year. This cut was accomplished primarily through across-the-board reductions in program support. In fiscal years 1984 and 1985, we will be operating under an additional 11 percent budget reduction to be accomplished almost completely in the personnel area.

While our goals, objectives, and priorities are more clearly defined and internal changes seem to have evolved somewhat naturally from our strategic planning efforts, major concerns exist regarding the quality and types of services we can now provide. The Office is operating more efficiently; however, shifting priorities and personnel changes necessitated by budget reductions have affected the number and nature of the responsibilities of individual staff members often resulting in a sense of being constantly overburdened.

Other developments during the year included:

- The successful merger of the Residential Programs and Student Activities sections of the Office into the Residence and Campus Activities Section.
- The design, in cooperation with the Offices of the Special Assistants to the President, and distribution of an informational leaflet on harassment.
- The conduct of a series of luncheon meetings during the Independent Activities Period and the second term on services provided to and special needs of graduate, international, women, minority, gay, and handicapped students.
- The renovation of the Infirmary into a 46-bed dormitory for graduate women students and its subsequent dedication in honor of Mrs. Ida Flansburgh Green.
- A highly successful community forum on pornography jointly sponsored with the Lecture Series Committee.
- The annual day-long ODSA planning and evaluation meeting held at Endicott House on June 8 at which we reviewed 1982-83 activities and outlined priorities for 1983-84.

In spite of all the changes and morale problems caused by the required budget reductions, the Office has had a very productive year. We were fortunate to have the services of three interns, John Wilson, Sulayman Clark and Marcia Weiss from the Harvard School of Education to complement the staff. I continue to be impressed with the talent and dedication of individual staff members and with their ability to adjust to change while having to function in a highly pressured environment. Of special note is the support provided to our Office this year by the Committee on Student Affairs under the chairmanship of Professor Campbell Searle. Professor Searle's personal interest and participation in many ODSA activities were especially encouraging and helpful.

SHIRLEY M. MCBAY

UNDERGRADUATE ACADEMIC SUPPORT

The Undergraduate Academic Support (UAS) Section coordinates the freshman advising and orientation programs for all new undergraduates, serves as an academic information center for students, individual faculty members, and departments, and acts as a catalyst for information exchange among departments. The major UAS programs are described below.

Freshman Advising Program

The structure of the freshman advising program has remained basically unchanged for the last several years. The primary counseling of freshmen during 1982-83 was carried out by 278 advisors (132 faculty, 23 lecturers/instructors, 22 research staff members, 24 graduate students, and 77 members of the administrative staff), an increase of 31 advisors over 1981-82. These advisors were supported by an almost equal number of undergraduates serving as "associate advisors."

Fifteen freshmen withdrew for a variety of personal reasons during the academic year, while seventeen additional freshmen were required to withdraw for at least one term because of unsatisfactory academic performance. The table below summarizes for the past four years the number of required withdrawals, the number of formal warnings of unsatisfactory performance given by the Committee on Academic Performance ("CAP Warnings"), and the number of the more informal letters from our office suggesting that the student review his or her performance.

Academic Year	Required Withdrawals	CAP Warnings	UAS Letters
1982-83	17	109	73
1981-82	8	93	98
1980-81	11	104	121
1979-80	16	106	93

This year the Committee on Educational Policy (CEP), with considerable involvement of our office, approved a new procedure to modify the ways in which the performance of freshmen is evaluated. The structure and handling of the mid-and end-of-term freshman performance evaluation forms has been changed considerably and an entirely new system for the formal awarding of internal grades for freshmen at the end of the second term has been instituted. These changes have been made to provide a more complete picture of freshman year performance to the students and their upcoming sophomore advisors.

Undesignated Sophomore Advising Program

The number of students choosing not to declare a major for some portion of their sophomore year increased slightly this past year, as did the number of advisors. Thirty-seven volunteer advisors drawn from faculty and staff were needed to provide a reasonable match of interests with 69 undesignated sophomores at the beginning of the fall semester and 32 in the spring.

Preprofessional Advising and Education

The Preprofessional Advising and Education component of the UAS has been relocated to new quarters under the auspices of the Office of Career Planning and Placement. This move, a part of the general effort at consolidation undertaken by all offices in response to required budget reductions, also involved the shift of Assistant Dean Jeannette Gerzon to the staff of that office.

Administrative Support to the Committee on Academic Performance

The Committee on Academic Performance (CAP) was chaired this year by Professor William Kaufmann and Jane Dickson continued to provide staff support to the Committee. During the year, the CAP handled approximately 450 petitions from individual students requesting readmission and exceptions to certain regulations of the faculty. A total of 95 Required Withdrawals (2.5 percent of the undergraduate student body) and 442 Warnings (9.5 percent of the undergraduate student body) were voted for the academic year.

The CAP support office continues to act as an information center for academically-related policies and procedures. The Committee's liaison with the counseling resources of the ODSA is in frequent use, both as a referral service for counseling and for input on particular students as background for the Committee's decisions. Over the last few years the Committee has observed a marked increase in the number of faculty members and students in general who come to the support office for advice and for information on faculty regulations and administrative procedures. This interaction has occurred outside the context of the formal Committee meetings and is a reassuring confirmation of the fact that the Committee and its support office are now viewed as a general resource for help and advice.

Undergraduate Seminar Program

The Undergraduate Seminar Program showed a decrease in the number of offerings this past year (from 53 to 42 in the fall semester and from 42 to 38 in the spring). However, the large number of students who choose to participate in the program continues to indicate that these seminars provide an important supplement to MIT's curriculum. Approximately 1,190 students, of whom 717 were freshmen, participated in seminars this year. Jeffrey Meldman served as interim chairman of the Undergraduate Seminar Program during the fall term and Professor Judah Schwartz was named Faculty Chairman this spring. Peggy Richardson continues to serve as Executive Officer of the program.

Academic Support and Information Center

The primary objectives of this activity area are to encourage a strong undergraduate academic support system for the benefit of both students and faculty advisors and to undertake or support efforts designed to improve the teaching of undergraduates.

Examples of our projects this past year are as follows:

1) Advised the Student Committee on Educational Policy (SCEP) during their subject evaluation efforts, including helping with the development of new humanities and laboratory evaluation forms and the successful evaluation of all Humanities Distribution subjects. The scope of this project is now substantial and the "Course Evaluation Guide" is quoted widely around the Institute.

2) Published a summary of how Teaching Assistants (TA's) are trained and used in the various academic departments, convened a working group on TA support, and participated in the Chemistry Department TA workshop.

3) Worked closely with the Associate Provost for Education, Professor Frank Perkins, in the development of programs to implement his new responsibilities.

4) In line with the CEP recommendation that departmental programs be clearly outlined for both students and their freshman advisors, developed a set of "roadmaps" to be published in the fall.

5) Undertook new measures to anticipate problems and provide support for students in academic difficulty in conjunction with other offices and departments by (a) developing better working relations with the Office of Minority Education, (b) working with the Undergraduate Offices and instructors of the major freshman subjects to develop an early warning system for freshmen identified as potentially in academic trouble, and (c) continuing to hold sessions in academic skills improvement during the fall term and IAP and developing new written materials to complement these sessions.

6) Enhanced links with and support for academic departments, especially in their Undergraduate Office and Open House programs and have continued to convene regular meetings of Undergraduate Office administrators to share information and to relay Institute policy changes that would directly affect their faculty and students.

Career and Course Orientation

Several activities designed to help students make decisions regarding departmental majors and career directions were carried out. The relocation of our drop-in center to the space formerly occupied by the Preprofessional Advising Office, Room 7-104, has allowed us to combine with and therefore increase the contents of and accessability to our reading room for undergraduates. This resource is serving as a central source of information to students about opportunities in the departments. The departmental "roadmaps" mentioned earlier will be available in the reading room and are specifically intended to be a valuable guide to students as they choose a major.

We have also supported several groups in their activities in this area such as the School of Science in its "Talking Science" symposium; the Baker Foundation, a student activities organization, in their freshman dinners; and numerous departments in their plans for departmental open houses.

Supervision and Coordination of Residence/Orientation

The Residence/Orientation (R/O) program, designed to welcome new students, especially freshmen, is produced almost entirely by undergraduates under the leadership of an R/O coordinator who is paid and supervised by the UAS Section. R/O Week 1982, under the coordination of Ken Dumas, Class of 1983, provided increased opportunities for students to become familiar with MIT and each other. Lillian Chiang, Class of 1984, is coordinating these efforts for the fall of 1983.

With the retirement of Dean Robert Holden, the UAS Section has assumed responsibility for transfer student orientation as well. We will be working with the academic departments of the incoming students over the summer and hope to involve them in this fall's orientation program in a more systematic manner than before.

This should make the transition of the transfer students to MIT a little smoother.

Staff

Staff within the UAS Section served as ex officio members on three faculty committees and held membership on several other Institute committees. Staff members met regularly with the academic subgroup of the Committee on Student Affairs.

On June 30, a substantial staff change takes place as Jane Dickson leaves her CAP support position after a long and productive association. For 13 years Jane has served the front-line function for the Committee, working with generations of Committee members and chairmen. Her extraordinary concern for students and her persistence in tracking down details have allowed the Committee to maintain continuity and give consistent, fair treatment to students. The goodwill her performance has generated was poignantly shown in comments from students and staff as Jane received a Murphy Award this spring.

HOLLIDAY C. HEINE
E. JANE DICKSON
JEFFREY A. MELDMAN
MARGARET S. RICHARDSON

STUDENT ASSISTANCE SERVICES

The Student Assistance Services (SAS) Section of the Office of the Dean for Student Affairs (ODSA) has held nearly 2600 individual counseling appointments this academic year. Of that number, 630 were made by women students and 580 by minority students. In addition, the International Students' Office interacted at least once with our more than 2000 international students. The work of the SAS over the year has been enhanced by some substantive changes that are described below.

One highlight occurred early in September when the integration of the International Students' Office into the SAS Section was completed. The result has been a greater unity of purpose and an increased awareness of the role this office plays in the experience international students have at MIT. The paperwork needed for international students can now be done by several individuals thereby increasing the responsiveness and sensitivity of the office as a whole.

A second major occurrence in the office was the loss of the half-time services of Assistant Dean Jeannette Gerzon. Dean Gerzon became Assistant Director of the Office of Career Planning and Placement when the Preprofessional Advising and Education function was transferred to that office in January. Her loss proved traumatic for it occurred at a time when we were experiencing a higher than usual number of serious counseling problems and a series of unexpected absences among the counseling staff.

From this adverse situation an extremely positive change in the office has resulted. Assistant Dean Leo Osgood joined the staff in April and has proved to be an effective and able replacement. He comes to us with extensive counseling experience and knows MIT well, having served as Assistant Basketball Coach for the past five years. Dean Osgood also brings additional minority presence to the office and gives us a desired connection to the Athletic Department where a great deal of counseling occurs.

We were also very fortunate during the second term to have the services of an intern, Marcia Weiss, from the Harvard Graduate School of Education. Ms. Weiss, came with extensive counseling experience and her work with students was excellent. She is the third intern SAS has had from Harvard over the last three years and the connection has been a mutually beneficial one.

A major highlight of the year had to be our growing use of the computer to take care of routine work. For example, we are now able to do I-20 forms for each international student using the computer, a task which had been extremely time-consuming and routine in the past.

Support to Special Student Groups

From a programmatic perspective, there were several highlights this past year. Dean Mary Hope continued to provide leadership for the Minority Discussion Groups with the support of Dean Eugene Chamberlain and others from this office. Follow-up meetings were held during the second term to the special IAP luncheon on issues facing minority students and support continues to be provided to minority-focused student organizations.

Of special interest is the fact that there were 75 minority students among this year's graduating seniors, representing the largest number to date. Included in this group were 57 Black Americans, 11 Mexican Americans, one American Indian, one Puerto Rican, and five students with Spanish surnames.

Dean Linda Vaughan headed the efforts of our office in support of women at MIT. The new staff associate's position filled by Sara Mae Berman has provided a sense of commitment by the Dean's Office to women students and it has served to centralize Institute-wide efforts on behalf of the students. Initiation of The Cheney Room Papers by Ms. Berman has also served to centralize the formerly fragmented efforts to keep women students informed of events and activities and other issues of value to the women's community.

We have undertaken renovation of the Cheney Room with funds from the Cheney Room endowment. A collaborative of women Architecture students has submitted a proposal for the necessary renovation and we hope to have the work completed by the end of the summer. In addition, the IAP/ODSA discussion group on women's issues met several times and has been supplemented by Cheney Room luncheon discussions where invited guests have shared their experiences with a large number of interested students and staff. Dean Vaughan has led an Eating Disorders Group for members of the community. The group began over IAP and will continue meeting throughout the summer.

Nightline continues to increase its visibility as a viable and valuable service resource to the MIT community. While we do not have the specific figures at this time, we have been informed that the number of telephone calls and drop-ins has increased over last year. The program manages to survive on a small budget and overall is in good shape.

Support for international students also improved during the year. Several meetings were held during the second term as a follow-up to the IAP luncheon on international students. One issue raised in these meetings, the need for international students to be included in the resume book published by the Office of Career Planning and Placement, was resolved by the decision to include international resumes in the future.

The foremost concern we have regarding international students involves the new government regulations that will go into effect August 1. Growing out of the Iranian debacle and our national inability to find international students, new regulations are going into effect that place greater responsibility upon host institutions for international students within their community. We are working hard to master these regulations and to disseminate information about their implications.

During the year, SAS continued to support the needs of other special student groups within the community. Efforts to continue building rapport with Gays at MIT (GAMIT) included financial support for IAP activities and participation in ODSA meetings with the leadership of GAMIT.

We are in the process of trying to make our support to handicapped students more visible. Meetings have been held with faculty, staff, and students bringing the issues to the forefront. Our efforts will continue in the year ahead to improve our awareness of the needs of disabled students in the student body and our services to them. Informational material is expected to be developed over the summer for general distribution this fall.

Other Developments

Dean Robert Randolph has continued to work with the Religious Counselors and the ODSA was instrumental in beginning the Chaplain's Lecture Series this year which was extremely successful.

Other efforts during the year worth noting include our support to various committees. Dean Robert Halfman, ODSA's representative to the Committee on Discipline, is preparing a full report for the faculty which will be ready in the fall. The Committee on Foreign Scholarships completed a successful year and will continue next year under Dean Chamberlain's leadership.

Budget cutbacks resulted also in the shifting of the Foreign Study Advising function to the Office of Career Planning and Placement, effective July 1. Relocation of these responsibilities meant the ending of the position held by Katherine Cutting. Mrs. Cutting leaves the office after having taken a function on the fringes of the Institute and moved it to a position of importance. Her commitment to her task has been admired by many.

We begin the new year with the office organized better than it ever has been. In appearance and function we have reached a high level of accomplishment. The future is bright.

ROBERT M. RANDOLPH
EUGENE R. CHAMBERLAIN
ROBERT L. HALFMAN
MARY O. HOPE
LEO OSGOOD
LINDA J. VAUGHAN

RESIDENCE AND CAMPUS ACTIVITIES

Institute Houses

The Institute Houses were once again filled beyond capacity with approximately 100 crowded rooms during the fall term. However, we were able to continue with the policy of providing on-campus housing accommodations for college transfers and readmitted students.

On October 2, 1982, two houses of the New West Campus Houses were named respectively for Dr. George W. Thorne, a Life Member Emeritus of the Corporation, and for Dr. James B. Fisk, Class of 1931, a Life Member until his death in August, 1981.

In February, 1983, renovation of the former Infirmary located at 350 Memorial Drive was completed and the facility was opened for occupancy as a 46-bed residence for graduate women. The dormitory was named in honor of Ida Flansburgh Green of Dallas, Texas, a major benefactor who has long been a particular friend to women pursuing graduate studies at MIT. Formal dedication of Ida Flansburgh Green Hall took place June 10, 1983 as part of MIT Technology Day.

The first suicide of an undergradute student in more than five years occurred in 500 Memorial Drive on February 8, 1983. The emotional impact of this tragic event was felt community-wide throughout the spring semester.

Over the past few years we have witnessed a steady increase in the number of undergraduate residents requesting permission to stay in their Houses for a ninth term in order to complete their degree requirements. A significant increase in the number of students staying in the dormitories is projected for this summer which seems, in part, to be the result of the inability of many students to find suitable off-campus summer employment.

Faculty and Graduate Residents

Faculty families in Residence leaving the system this year included Professor James H. Williams, Jr. and Ms. Karen Goodall of New West Campus Houses, Professor Michael Marletta and Ms. Jennifer Brunn of Burton House, and Professor and Mrs. Jeffrey Lang of New West Campus Houses.

Additions to the system included Professor Edith Waldstein and her husband, Frederic of Green Hall, Professor Alan Hatton and his wife, Marianne of MacGregor House, and Mrs. Gloria Pless who was recently married to Professor Irwin Pless, Faculty Resident in Random Hall.

Professor Derek Rowell and his wife Allison, formerly in MacGregor House have become the Senior Faculty Family in Residence in New West Campus Houses.

Faculty and Graduate Residents continue to be an invaluable resource in the implementation of our successful residential program. These individuals immerse themselves in the lives of the residents and assist greatly in their personal growth and development.

Dining and Residence Programs

The third year of the new residential dining program went very well. Commons Committees in the Houses met regularly with Food Service and Dean's Office staff and a Commons Committee was established for Lobdell Dining Room. The Dining Advisory Board held monthly meetings to review campus-wide dining policies and at its last meeting, the Board unanimously recommended that the dining room at 500 Memorial Drive switch from a "commons" to an "a la carte" system for 1983-84 as an experiment.

In another development, the construction of kitchens in East Campus and Senior Houses is expected to be completed by next September and students in these two houses will no longer be on a mandatory meal plan.

Fraternities and Independent Living Groups

A major effort was made this past year to encourage the development of uniform house judicial procedures and community standards throughout the fraternity system. Unfortunately, this was not a very successful effort. In fact, irresponsible behavior, usually justified as "hacks" or traditional "pledge raids" reached an unacceptably high level. Three fraternities were placed on Dean's Office Probation, bringing the total number of houses on such probation to five.

On a brighter note, Phi Beta Epsilon received the Kenneth R. Wadleigh Award in recognition of a very impressive series of faculty programs in their house throughout the year and Delta Tau Delta received the James R. Killian Community Service Award for an outstanding and comprehensive community service program.

Other developments during the year included renovation projects in Theta Delta Chi and in Theta Xi; the revitalization of Infocus, the Interfraternity Conference newsletter; initial discussions with an existing Black fraternity and a Black sorority regarding IFC membership; and the pledging by Club Amherst of the Alpha Phi Women's Fraternity.

Alumni Interfraternity Conference Steering Committee (AIFC)

Late in the year, a special meeting was organizied by the IFC in order to draft a white paper describing the distribution of roles among the IFC, the AIFC, and the ODSA. In the face of reduced support from the Institute, the AIFC plans a liaison program whereby AIFC Steering Committee members would be responsible for maintaining contact with two or three assigned houses to provide an "early warning system" for potential problems as well as a communications link on issues. Under the proposal, the IFC would assume additional responsibility for workshops and liaison with undergraduate chapters while the ODSA would provide assistance to Houses in handling very critical issues as well as provide administrative support for the AIFC.

The plan marks an important stage in the development and role of the Independent System. The AIFC/IFC response is again representative of the responsible problem-solving orientation of their respective groups.

The Merger

The most difficult aspect of the merger of the "Residence Programs" and "Student Activities" Sections of the ODSA into the "Residence and Campus Activities" Section was adjusting our schedules and modifying our priorities. New roles and responsibilities shared among Peter Brown, Robert Sherwood, Sandra Nett, Anita Walton, and Stephen Immerman have placed considerable strain on overall quality attention to programs. Close monitoring and reprioritizing of schedules may serve to ameliorate this somewhat in the future as familiarity and ease with new roles and responsibilties become more routine and as other ODSA staff members provide increasing assistance.

The Visiting Committee

Preparing for the Visiting Committee was particularly helpful in assessing the current state of affairs in student activities. As a result of the Committee's visit and meetings held before and after the visit, several issues were identified which are expected to require our attention for the next few years.

These issues include the following:

1) The business practices of student organizations must be upgraded to at least minimally comply with Institute and legal standards;

2) a revised system for allocating scarce resources must be developed and implemented in order to better share money and space in a fair and equitable way among student activities;

3) efforts are needed to improve the effectiveness of the undergraduate government, for in its current form it seems incapable of representing its consituencies or of developing consensus on issues of community importance;

4) a sense of accountability and responsibility to the community needs to be more clearly reflected in the policies and programs of some student organizations; and

5) space for activities needs to be better managed including ongoing maintenance programs designed and funded to provide for long-term health.

In addition, considerable concern was generated during the Committee's visit about the lack of time available for students to participate in activities. There is also a need to examine the potential impact of increasing financial constraints on choices students may have to make between work and participation in extracurricular activities.

Campus Activities

An ad hoc committee on Student Activity space, chaired by Dean Robert Sherwood, met throughout the spring term to review the physical condition of the facilities and furnishings currently being used by student activities; to develop a priority list and timetable for carrying out any necessary improvements; to review existing and potential sources of income to finance any such improvements; to review and comment upon leases held by the Co-op, Post Office, etc; to review the existing organizational structure as it pertains to the assignment of space for student activities and make recommendations for streamlining it; and to make recommendations for a long-range repair/renovation program. An interim report is expected from the committee during the summer.

In a cooperative effort, the Physical Plant and the Student Center Committee evaluated furniture needs of student center student office spaces and allocated $16,000 for furniture repair and replacement.

In another exciting development, the Class of 1983 voted to establish a student art gallery in the Student Center as their class gift. Entitled "The Jerome B. Weisner Art Gallery", the facility is planned for the East Lounge area of the Stratton Student Center and will be used to bring attention to student art on campus. Andrew Eisenmann will supervise the gallery program and operation when it is completed.

Anita Walton accepted the new responsibility as coordinator of the Institute's Award Convocation and, following months of planning, the Convocation was an outstanding campus-wide event.

Considerable campus attention was focused on the issue of pornography this year. The controversy produced some very positive outcomes including several letters to The Tech and considerable campus dialogue. Under Dean McBay's leadership, a committee of faculty, staff, and students held several meetings which resulted in the screening of the movie "Not a Love Story" followed by a panel discussion of MIT faculty on the movie and topic. It is unclear at this time what LSC plans are for showing pornographic films in the future, however, the LSC or the ODSA will need to provide some alternative programming for any such occasions.

In response to the Visiting Committee review, the Undergraduate Association (UA) has organized a group of major student leaders as "The UA Advisory Committee." The group's charge is to review the structure and purpose of the Undergraduate Government hopefully leading to significant and positive changes in the UA.

Members of the Internal Audit Division met with student leaders to discuss issues relating to the business practices of student organizations including reporting requirements for employers and for the Internal Revenue Service. These issues as well as strategies for implementing compliance will be a major agenda item for the fall.

Student Center Art Studios

This year's total enrollment of 690 in courses offered by the students was somewhat below the previous six-year average of 732; however, student enrollment (374) was one of the best ever.

Other developments include the creation of a gallery at the Brookes Center facility at Endicott House where art from the Student Center Art Studios will hang. The Advisory Committee to the Student Art Association met four times in the spring of 1983 to discuss, clarify, and attempt to resolve issues of policy, operation and program, and future directions. The Board will continue to meet at least three times per year, acting in an oversight capacity and providing ongoing support and direction for the Student Center Art Studios.

Graduate Student Housing

After two years of meetings and analysis of data from the 1980 Graduate Student Housing and Transportation Survey, the Administrative Housing Group (AHG) chaired by Dean McBay, published its recommendations in a report containing policy papers on pricing, capacity, and access and tenure in housing.

In an effort to increase the availability of resources for graduate student housing, the pricing paper recommended that the Institute recover its costs, both capital and operating, and build up capital funds to increase the availability of new graduate student housing from current graduate student housing fees. All new revenues generated from any room rate increases beyond those necessary to recover operating costs were to be set aside in a Graduate Housing Reserve Fund to increase the availability of graduate student housing. The renovation of the Infirmary for use as housing for graduate women represents the first tangible result of this fund.

Recommendations from the capacity and the access and tenure policy papers reaffirmed the Institute's long-range goal of providing housing for 50 percent of both its married and single graduate students. Based on present enrollments, this would mean adding approximately 400 single and 300 married student spaces to the present housing stock. The access and tenure paper also recommended the assignment of 50 percent of all available spaces to new graduate students.

Graduate Students

Several significant events made 1982-83 a special year for graduate students. Opening this year, after a several-year hiatus, was the Thirsty Ear Pub in the basement of Ashdown House. The Pub provides a much needed multipurpose social facility for graduate students, especially those residing on-campus.

The Muddy Charles Pub located in Walker Memorial continues to thrive, despite a difficult period of adjustment with a change of managers. A positive sign for the future was the stabilizing leadership provided during this time of transition by the Board of Governors of the Pub which consists of graduate students, staff, and faculty patrons.

Finally, the continued development of the resident associations in the graduate living units of Tang Hall, Ashdown House, Eastgate, and Westgate provides a network of helpful communication and community services to the on-campus graduate student residents. Of particular note were the programs and efforts in Tang Hall and Eastgate.

Graduate Student Council (GSC)

A major highlight this past year was the outstanding leadership provided by Council's President, Luu Nguyen. Under his direction, the GSC had one of its most productive years. Council meetings were well attended and featured persons from many parts of the Institute who spoke to issues currently facing graduate students. The Council's committees were involved in several key projects that increased the visibility and viability of the GSC. One such project was The Graduate magazine of which there were five highly informative editions. Luu Nguyen was the catalyst for much of the activity and for his outstanding leadership and selfless contributions to the community he received a Compton Award. In addition, The Graduate and its editors received a Stewart Award at this year's Award Convocation.

Another major factor in the successful year that the GSC experienced was the active support which the Council received from their Administrative Assistant, Joanne Baldine. In addition to carrying out her regularly assigned responsibilities, she provided special efforts during graduate student orientation in the fall, contributed to The Graduate magazine, and did a follow-up on the 1978 Dober Report which examined the quality of life for graduate students. At the request of the ODSA and the GSC, Ms. Baldine visited all 22 graduate departments to see what, if any, changes might have been made as a result of recommendations contained in the Dober Report. Her observations published in The Graduate this past February offered examples of highly involved and concerned departments, and challenges to those departments that are still working to relieve academic pressures on graduate students.

The GSC meeting area, the Chalmers International Students Lounge, underwent a substantial and much needed facelifting this past year. With funding from the ODSA and Physical Plant, the GSC had the lounge painted and carpeted and the furniture reupholstered. The result is a startling improvement.

Non-Resident Students Association (NRSA)

The 1982-83 academic year saw NRSA emerge from a state of organizational and physical disrepair. The original purpose of NRSA, to provide support and a sense of identity to undergraduate student commuters, has slowly eroded as the commuter population has declined. Use of the facility had dropped off steadily until this year when an energetic group of students emerged to pump life back into the organization.

NRSA plans to broaden its approach to include all Institute non-residents, especially the almost 3,000 non-resident graduate students. In addition, the organization intends to be more active in fall and spring orientation programs and in establishing a calendar of social events for the non-resident community. With a revitalized student organization and an improved facility, NRSA's future looks bright.

Talbot House

It was another busy year at the Talbot House as 1202 students from 58 groups visited the Institute's retreat house in S. Pomfret, Vermont. During the 1982-83 academic year, Talbot House was occupied 45 weekends with 13 groups making visits during the week. The House continues to attract individuals from all facets of the MIT community with representation from 19 academic groups, 13 living groups, 10 associations or clubs, 11 recreation groups, and five faculty/staff groups. January and February were the most active months with nine different groups taking advantage of the winter sports season during IAP.

Many minor improvements were made to the property this year and a client team of frequent visitors to the house began meeting this spring to plan for some long-range projects and improvements.

Discipline

Several discipline cases involving students from living groups were adjudicated by staff in the RCA Section of the Dean's Office. Three students were suspended from their residences, two were declared persona non grata, twelve were placed on Dean's Office Disciplinary Probations, seven were given Dean's Office Disciplinary Warnings, and three fraternities were placed on Dean's Office Probation. Offenses included such things as breaking and entering, stealing, malicious destruction of property, unacceptable "hacking", continued disturbance of neighbors, harassment, assault and battery, drug use, setting off fire crackers, setting a fire, and refusal to evacuate during a fire alarm.

Other Developments

Members of the RCA Section served on some 25 committees, 14 of which were student activity-related and, in addition, served in advisory roles to the major student governing groups and student organizations.

Staff in the Section attended three professional conferences during the year and held membership in five professional organizations. In addition, Andrew Eisenmann served as Acting Director of the Student Art Association and Kathleen Haskell as Acting Staff Associate while Malka Kutnick and Barbara Chuck respectively were on leave. Finally, Stephen Immerman's title was changed from Business Advisor to Fraternities to Assistant Dean for Student Affairs to more accurately reflect his new responsibilities following the merger.

ROBERT A. SHERWOOD
STEPHEN D. IMMERMAN
PETER H. BROWN
ANITA T. WALTON
SARA MAE BERMAN
BARBARA CHUCK

Attachments: Fall, 1982, Institute House Count
Fall, 1982, Regular Graduate Student Residential Distribution

INSTITUTE UNDERGRADUATE HOUSE COUNT

Fall 1982

HOUSE	1		2		3		4		Other		Total		TOTAL	CAP	VACANCIES	CROWDS
	M	F	M	F	M	F	M	F	M	F	M	F				
Baker	40	35	45	29	61	39	75	17	1		222	120	342	337	2	7
Bexley	20	4	10	5	36	6	26	11			92	26	118	122	4	0
Burton	66	30	35	33	57	43	63	36	2	1	223	143	366	344	0	22
East Campus	102	28	48	18	103	16	72	17			325	79	404	367	0	37
MacGregor	105		64		73		82		2		326		326	326	0	0
McCormick		58		54		66		54				232	232	219	0	13
New House	51	12	52	5	39	6	54	3	2		198	26	224	211	0	13
French	4	2	2	2	3	5	7				16	9	25	24	0	1
German	3	1	3	1	4	3	5	1			15	6	21	21	0	0
Russian	4	2	6		1	2	4				15	4	19	18	0	1
Spanish	5	1		4	3	1	3		1		12	6	18	18	0	0
Random	22	2	18	9	15	11	11	2			66	24	90	93	3	0
Senior House	36	7	24	11	40	6	45	11			145	35	180	183	3	0
500 Mem. Dr.	53	48	137	60	36	7	26	8	1		253	123	376	352	0	24
TOTAL	511	230	444	231	471	211	473	160	9	1	1908	833				
	741		675		682		633		10		2741		2741	2635	12	118

RESIDENTIAL DISTRIBUTION OF MIT STUDENTS

Fall Term, 1981-82

Regular Graduate Students

MIT HOUSING	Men	Women	Total
Ashdown	314	71	385
Tang	348	56	404
Graduate Residents (Single)	23	16	39
Total Single Graduates -- On Campus	685 (19.4%)	143 (17.6%)	828 (19.0%)
Eastgate*	177	26	203
Westgate	193	16	209
Graduate Residents (Married)	22	10	32
Total Married Graduates -- On Campus	392 (11.0%)	52 (6.4%)	444 (10.2%)
Total Graduates -- On Campus	1077 (30.4%)	195 (24.0%)	1272 (29.2%)
OFF CAMPUS	2462 (69.6%)	615 (76.0%)	3077 (70.8%)
TOTAL REGULAR GRADUATES	3539 (100.0%)	810 (100.0%)	4349 (100.0%)

*There are six couples in Eastgate where both members are students, and five Graduate Resident couples where both members are students.

Department of Athletics

This report, my third as Director of the Department of Athletics, Physical Education, and Recreation, will present concisely and for permanent record a statistical review of the wide-ranging athletic and recreational programs and special events our Department conducts for the MIT Community.

GENERAL OVERVIEW

Academic year 1982-83 was comparable to the strong previous year 1981-82 in showing broad-based student participation in all programs of the MIT Department of Athletics, Physical Education, and Recreation (see Exhibit I). Undergraduate registrations in Physical Education have increased for the fourth consecutive year (see Exhibit II), while graduate and staff registrations have reached new highs. The Club Sports program has one addition reaching an all-time high in number of participants and programs (see Exhibit III). Women's student intercollegiate participation shows a slight increase, and men's intercollegiates show a small decline both consistent with the 1982-83 total student enrollment swings. Combined undergraduate participation in intercollegiate athletics is over 17% (vs. 18% year ago). Intramurals enjoyed a significant increase in overall number of teams and individual participations (see Exhibit IV), while adding two new programs bringing the total programs to 29. Intramural athletics continues to have the largest student participation with over 60% of the total undergraduate enrollment involved in at least one program.

PHYSICAL EDUCATION

In the final year of Professor Edward Crocker's long and effective tenure as Director of Physical Education, the program enjoyed another increase to new highs in total student registrations (6,521 vs. 6,098 year ago) and number of classes offered. Reflecting the increase in MIT graduate students and our commensurate commitment to them, we are also pleased to report a significant increase in graduate student registrations (827 vs. 633 year ago). Staff registrations increased by 35 to 310.

The Physical Education 1982-83 curriculum (see Exhibit II) continues to offer a broad variety of offerings including the addition of "Personal Health Fitness" - a trial course developed by Coordinator of Sports Medicine, Paul Grace, involving 17 students and designed to measure and evaluate various body fitness components including muscular strength, cardiorespiratory efficiency, active flexibility, body fat percentages, and diet patterns. Subsequent to analysis, the course examines possible individual options for exercise, diet, and general physical activity. Student responses were encouraging, and plans are being developed to expand this Personal Health Fitness concept in the 1983-84 academic year.

Our decision with Instructor Riva Gibley to expand the dance offerings has allowed that program to continue as most popular with an increase of almost 100 registrants (total 684 vs. 593 year ago). Consistent with the strong health fitness social movement in this country, we report Weight Room Strength and Flexibility Development and Self-Designed Fitness continue as our next two most popular offerings - both showing strong increases over last year. Professor Crocker and I would make particular mention of the outstanding job of first year Instructor Halston Taylor who assumed responsibility for the Weight Room Development Program and stimulated a surge of new student and general community interest. Halston's leadership is one more justification for the new Class of 1974 Intramural Health Fitness Center which will be ready by September of 1983. We would also make special mention of the retirement of Maggie Lettvin, the founder of the Self-Designed Fitness Program. Her vision anticipated the growing importance of individualized fitness, and her drive over 17 years gave thousands of MIT students, faculty, and staff the opportunity and environment to appreciate and realize fitter bodies. Maggie will be missed, and we are committed to sustaining her legacy.

We welcome Associate Professor Gordon Kelly as the new Director of Physical Education after serving our Department in a number of important responsibilities including Acting Director of Physical Education during Professor Crocker's sabatical leave and most recently Assistant Director. Professor Kelly supports the steps taken to undergird the Physical Education Program initiated in Professor Crocker's final years (discussed in last year's Annual Report) and plans a number of his own innovations in curriculum, student requirements, outside activity credit, and advanced placement procedures. These plans will be discussed in detail with the MIT Visiting Committee scheduled for late October, 1983.

CLUB ATHLETICS

With the addition of Women's Soccer, the revival of Square Dance and Judo, and the continuing activity of all last year's Clubs, the 1982-83 Club Program under Assistant Director Jack Barry's leadership once again reached all-time highs in number of programs and student participation (see Exhibit III).

Professor Barry reports a dramatic increase in the strength and organization of the already successful women's clubs of Lacrosse and Ice Hockey. These two, plus Women's Soccer, all seem to be moving toward possible varsity intercollegiate status. It will soon have to be decided whether club or varsity intercollegiate status would best serve these blossoming activities.

The most outstanding single event of the 1982-83 Club season was the two-year-old Bowling Club 1st place finish of Mark Helder, Class of 1984, at the American College Union Tournament.

INTERCOLLEGIATE ATHLETICS

For the second consecutive year, MIT offers its undergraduate men and women 32 athletic programs of high level Division III NCAA (or equivalent) intercollegiate competition and skill development (see Exhibit V). These 32 programs, plus the Club Varsity intercollegiate sports of Football and Men's Ice Hockey, represent an MIT all-time high of 34 intercollegiate programs involving 876 students (19% of total undergraduate enrollment). Exhibit V also indicates the improved win-loss success of our intercollegiate teams. The men's intercollegiate teams achieved a solid .556 winning percentage (up from .481 last year) and had 12 (vs. 9 last year) out of 19 won-loss record teams with a winning edge.

The women's intercollegiate programs realized a significant increase in won-loss success with an impressive .613 winning percentage (vs. .441 last year) and with 4 teams out of 10 (Cross Country, Volleyball, Fencing, and Softball) achieving winning seasons vs. only two a year ago. Exhibits VI, VII, VIII, and IX recap various men's and women's individual and team achievements during their respective 1982-83 intercollegiate seasons or post-season competition.

In April, 1983, the memberships of the Eastern Association for Intercollegiate Athletics for Women and the Eastern Collegiate Athletic Conference voted to consolidate the two regional NCAA athletic conferences under the name "Eastern Collegiate Athletic Conference." This ends an era of sex-separate regional athletic governing bodies for men and women. Jane Betts, Assistant Director of Athletics, served on the committee that designed the consolidation proposal. She will also serve for two years on the Executive Council of the consolidated organization.

CHAMPIONSHIP COMPETITION HOSTED BY MIT

Again this year, the excellence of MIT's indoor and outdoor athletic facilities brings many requests to host intercollegiate and club championships. In deciding what to host, our primary criteria is to enhance the competitive environment for our own students with the enhancement of the particular sport as another important consideration. MIT is committed to a leadership role in intercollegiate athletics for our students and the broader society, and we therefore must be prepared to assume a major role in the effective management of championship events. With this philosophy, care has to be exercised to prevent depriving our own MIT Community through the scheduling of excessive championships or other special events.

This year, Coordinator of Special Events Jack Barry and our MIT Athletic Board have established a Facilities Committee to set guidelines for responsible control of championship event scheduling. The Facilities Committee has recommended only one of our three major indoor areas (du Pont Gymnasium, Rockwell Cage, Athletics Center) to be used at any one time for a tournament/championship event involving outside schools and MIT teams. This limit will preserve two buildings for general student use at all times. In addition, the Facilities Committee has urged responsible efforts to schedule those events, whenever possible, at times which do not conflict with the peak MIT student usage periods. The 1982-83 Championships and Special Events hosted at MIT are listed on Exhibit X.

COMMUNITY RELATIONS AND GENERAL RECREATION

1) Instruction and Recreation for the MIT Community

Our Department of Athletics has sustained a broad series of program offerings for MIT Community children plus eight weeks of MIT Summer Day Camp for some 210 MIT children per week.

Adult instructional programs were again offered in Self-Designed Fitness, Weight Room Technique and Body Development, Cardiopulmonary Resuscitation, Golf, Sailing, Wind Surfing, Swimming, Sculling, Tennis, and Dance.

2) Athletic Card Sales (See Exhibit XII)

Despite the doubling of student fee rates to $10.00 and various smaller percentage increases for other user groups, athletic card sales continue strong, and the dollar volume has increased significantly meeting all budget objectives. The Sailing Program/Nautical Association membership levels also are holding well with the difficult fall and spring winds and weather viewed as part of the reason for some fall-off in total membership. We believe the MIT retrenchment process and personnel reductions can also be attributed to some of the softness in both Athletic Card and Sailing Program Membership Card sales levels.

3) Boston/Cambridge Community Relations (See Exhibit XI)

The 1982-83 year saw another increase in the ties between MIT and the surrounding community through the use of MIT athletic facilities. The new MIT Athletics Center and our improved indoor and outdoor track facilities result in many requests at the Cambridge and Boston city level, as well as statewide requests. We were able to meet most City of Cambridge requests including those from Cambridge Public Schools, Cambridge Recreation Department, Cambridge Boys and Girls Club, and various other Cambridge groups as listed in Exhibit XI.

The new MIT Athletics Center has become the home of the Massachusetts State Science Fair and has proved very effective for such an event. Also on the state level, MIT hosted the Massachusetts State Police Junior Olympic Games and the Bay State Games sponsored by the Governor's Council on Physical Fitness.

We will continue to pursue a policy of Community outreach and facility availability where appropriate and not in conflict with student and general MIT Community usage.

MIT ATHLETIC FACILITIES

1) Facilities Operations - Under the strong and consistently effective leadership of Assistant Director of Athletics Jane Betts, the facilities operations fall basically into two categories: (a) on-going day-to-day services essential to the overall conduct of our many programs and (b) coordination with Physical Plant and/or outside suppliers/contractors to effect necessary facility improvements to expand opportunities for the MIT Community. During the year 1982-83, three major projects were completed:

i) Four permanent suspended basketball backboards were installed on the West side of Rockwell Cage. The boards are creatively designed to be manually moveable to accommodate net court games without overhanging interference. The backboards provide two high-quality basketball courts and have been well received.

ii) The damaged baseball backstop fence was replaced and a ten-foot high net fabric was suspended from outriggers welded to the backstop. The arrangement will allow baseball players to execute a valuable hitting drill into the backstop without damaging the fence.

iii) A document of policies and procedures for outdoor athletic field use and maintenance was collaboratively produced by personnel in the Athletic Department and Physical Plant. The document provided first-time guide lines for outdoor programs and was implemented this spring. The result was a smooth operation and a much-improved and productive relationship between the users and grounds personnel.

In addition, there are two projects nearing the final stages of completion:

i) The Class of 1974 Intramural Health Fitness Center, a modern fitness facility renovating the old Weight Room, will be open in September 1983. The Center is in W32-0040-0038. Renovation of the space was funded by the CRSP Committee. The Class of 1974 Fund supported the purchase of eight Nautilus machines and approximately 50 pieces of free-weight equipment.

ii) To facilitate more efficient use of space to enhance spectator seating and modernize the interior of Rockwell Cage, one section of telescoping bleachers will be removed from the MIT Athletics Center Ice Rink and installed along the East wall of Rockwell Cage.

There are several additional projects in various stages of development including restoration of the Carr Tennis Bubble following last year's collapse, the relamping of Rockwell Cage, improved weight training facilites at Pierce Boathouse, improved playfield surfaces on outdoor Areas A and B, improved lighting in the Athletics Center 2nd level, and an outdoor public address system at Pierce Boathouse.

2) Physical Plant Personnel Transition - In October, 1982, the Athletic Department took over the management and supervision of personnel at the Pierce Boathouse and Alumni Pool. Previously, this phase of the operation of these facilities was the responsibility of Physical Plant. The transition was smooth. Primarily, it involved budget transfer for salaries and the appointment of John Benedick and Peter Holland to directly supervise lifeguards and boatmen at the Pool and Boathouse respectively. This change in facility operation has improved efficiency and overall departmental coordination.

3) New Reservation System - Continued efforts to improve the scheduling and operation of facilities brought about a change in the basic reservation form. This change added material having to do with the operation of the facility on the back of the schedule form and called for the operation officer's signature on the form, thus insuring that all of the scheduling and operational needs could be handled at one time with only one visit. This has proved helpful.

Another innovation that has aided the scheduling efficiency has been the large weekly schedule board at the ice rink. This board has been most helpful in publicizing any schedule changes well in advance

and keeping the schedule right in front of the user. So successful has this system been at the Rink that the Department is planning to establish a similar board at the Pool.

SPORTS MEDICINE/TECHNOLOGY HEALTH FITNESS

Under the continuing strong, creative leadership of Paul Grace, Coordinator of Sports Medicine, our new Co-Educational Athletic Training Facility in du Pont has brought a significant improvement in the delivery of student services to a point where we believe optimal care is being provided. The planned purchase of additional rehabilitation equipment, a careful system of record-keeping established for injuries, treatment mode, and supplies, and improvement of the ventilation system will complete the upgrading of professional atmosphere and service delivery and allow the facility to function as we all expected it would.

Paul Grace has effectively developed the Technology Health Fitness interdepartmental relationship with Professor Robert Mann and the Department of Mechanical Engineering. Together we conducted five student research projects. We continue to work with the Harvard-MIT Health Sciences and Technology Division with particular emphasis on one major instrumentation project with Professor Stephen Burns. Our Department has also had some preliminary discussions with the Psychology and Electrical Engineering Departments on some co-directed research projects.

Sports Medicine goals for 1983-84 include:

1) Maintain and develop interdepartmental relationships to expand the Technology Health Fitness effort.

2) Strengthen the working relationship and important collaboration with the MIT Medical Department. The 1983-84 year will bring a new liaison physician, Dr. Mark Goldstein, replacing Dr. Edward Rendall as a member of the Athletic Board and as our primary linkage with the Medical Department personnel, policies and services.

3) Continue and strengthen the relationship with Northeastern University's Sports Medicine Department - students and faculty.

4) Assist the Physical Education Department in the assimilation of the new "Personal Health Fitness" concept into the curriculum menu.

5) Serve as a helpful resource in achieving optimum effectiveness in the operation of our new Class of 1974 Intramural Health Fitness Center.

SPORTS PUBLICITY AND COMMUNICATIONS

Director Ken Cerino and the Sports Information Office had another exciting and productive year providing on-going student program support and assisting in hosting major tournaments ranging from the open round game of the NCAA Division III Women's Volleyball Championships in the fall to the New England Division III Outdoor Track & Field Championships in the spring. In addition, the SI Office provided major publicity support for the 1982 Frostbite Classic Road Race, the 1983 Community Service Fund Road Race, the newly formed MIT Activities Committee, and the 1983 Bay State Games.

The most extraordinary accomplishment of Ken Cerino's Office was the selection of an unprecedented five MIT students to various Academic all-America squads as voted by the College Sports Information Directors of America (CoSIDA). They were Robert Joseph, Class of 1983 (Basketball), honorable mention; Louise Jandura, Class of 1984 (Softball), first-team; Ken Shull, Class of 1984 (Wrestling/At Large), first-team; John Schmitz, Class of 1983 (Swimming/At Large), first-team; and John Friedman, Class of 1983 (Water Polo/At Large), first-team. Joseph was featured in the Boston Globe in February, while Friedman was the recipient of a NCAA postgraduate scholarship worth $2,000.

Other accomplishments in 1982-83 include:

- Continued success with hometown articles on MIT student athletes. This project always will have a high priority for the SI operation;

- Preparation of a general information sheet describing the MIT athletic program for use by coaches and Admissions Office personnel;

- Coordination with THE TECH (MIT's undergraduate student newspaper) and its sports desk in providing additional coverage of Athletic Department programs, especially varsity athletic events;

- Publication of several articles and pictures in TECHNOLOGY REVIEW for MIT's interested and supportive alumni;

- Compilation for the first time of a complete list of varsity letterwinners at MIT along with year-by-year results (from available sources) of the various varsity sports teams for men and women (including

coaching records, most valuable players, and captains);

- Chairing of a department committee which is in the process of changing criteria (in some cases) for the Straight "T" Award which is the highest award for athletic excellence at MIT;

- Service on a departmental office equipment committee planning and discussing ways in which a word processing/computer system might enable the Department to operate in a more efficient manner. The result was the purchase of two DECMate II systems.

For 1983-84, the SI Office, working with Historical Collections, plans a renovation of the trophy case area in the du Pont/Rockwell Cage lobby area to highlight outstanding MIT individuals and teams.

The Department is examining the possible publication of a newsletter and general guide on MIT Athletics. More research has to be done in cost-saving techniques before such publications are printed.

ATHLETIC DEPARTMENT STAFF

We have an outstanding staff of professional coaches, instructors, administrators, utility, and clerical personnel at all levels. A major responsibility of the Director is to help create and preserve a responsible and responsive environment for their successful leadership of our students and for our MIT Community to enjoy a satisfactory athletic/recreational experience.

A year ago, we developed together a sound budget retrenchment plan, and this year we have proven equally committed to the plan's effective implementation. I want to make special mention of the reasoned and positive attitudes of our collective Department in meeting the financial challenges of this period in MIT's history.

STAFF ACCOMPLISHMENTS 1982-83

Walter Alessi, Head Coach of Lacrosse and Soccer, served as Head Coach of the East All-Stars in the annual New England East-West all-star game held at Trinity College.

Jack Barry, Assistant Director of Athletics and Head Golf Coach, served as the Director of the Greater Boston Conference Golf Tournament, was Vice-President of the New England Intercollegiate Golf Association, and was a member of the NCAA Division III Selection Committee for the National Tournament.

John Benedick, Head Coach of Men's and Women's Swimming and Head Coach of Water Polo, was a member of the NCAA Water Polo Committee.

Jane Betts, Assistant Director of Athletics, was a member of a joint committee that worked for one year on the consolidation of the Eastern Association for Intercollegiate Athletics for Women (EAIAW) and the Eastern College Athletic Conference (ECAC). This past spring, both organizations accepted the consolidation proposal. Betts will serve as a member of the 15-member ECAC Council for the next two years.

Ken Cerino, Director of Sports Information, served as President of the ECAC Sports Information Directors Association and was the publicity director of the Greater Boston Conference Baseball League.

Mayrene Earle, Head Coach of Women's Crew, served as a Crew team manager at the National Sports Festival in Colorado Springs, Colorado.

Gordon Kelly, Head Coach of Track, was named New England Division III Indoor and Outdoor Track Coach of the Year (for the second straight year) by the New England Track Coaches Association. Kelly is presently the President of the New England Division III Track Coaches Association.

Candy Royer, Head Coach of Women's Tennis, was named to the Intercollegiate Tennis Coaches Association Women's Operating Committee. She has also been named to the ECAC Women's Tennis Committee.

Tim Walsh, Head Coach of Wrestling, was named New England College Conference Wrestling Association Coach of the Year for the second time in the last four years.

STAFF CHANGES 1982-83

New Appointments (Effective 1982-83)

Taylor, Halston W., Instructor in Physical Education, Head Coach Men's Cross Country, Assistant Coach Track and Field, Liaison Coordinator of MIT Body Development Program and Weight Room Facility.

Molesso, Francis, Head Coach of Men's Gymnastics - part-time.

Neczypor, Francis, Head Coach of Lightweight Crew - part-time (promoted from Freshman Coach).

Scarabino, Frank, Head Coach Women's Club Ice Hockey - part-time.

Promotions

Earle, Mayrene, to Head Coach Women's Crew and Instructor in Physical Education - full-time effective 1983-84 (promoted from Freshman Coach - part-time).

Heiney, Jean, to tenured Associate Professor effective 1983-84.

Malone, William, to Administrative Staff (promoted from Exempt).

Smith, Dwight, to Assistant Professor (promoted from Instructor).

Retired or Relocation Outside MIT

Crocker, Edward - Retired as Associate Professor and Director of Physical Education; Head Coach Men's Squash and Tennis.

Castanon, David - Head Coach Women's Volleyball - part-time.

Clark, Douglas - Instructor in Physical Education; Head Coach Women's Crew.

Fleckles, Andrea - Coach of Men's and Women's Diving; Instructor - part-time.

Lally, Jo-Anne - Assistant Coach Men's and Women's Swimming - part-time.

Lettvin, Margaret - Instructor in Physical Education and Coordinator of Self-Designed Fitness Program - part-time.

Pearce, Harriett - Instructor in Physical Education; Athletic Trainer.

ROYCE N. FLIPPIN, JR.

EXHIBIT I

M I T ATHLETIC PROGRAM PARTICIPATION

	Report Year 1982-83	1981-82	1980-81
STUDENT ENROLLMENT (October Figures - includes Specials)			
Undergrad Women	1,048	977	891
Undergrad Men	3,571	3,585	3,686
TOTAL	4,619	4,562	4,577
Graduate Women	929	786	846
Graduate Men	3,927	3,649	3,942
TOTAL	4,856	4,435	4,788
GRAND TOTAL STUDENTS	9,475	8,997	9,365
STUDENT PARTICIPATIONS (Includes Multiple Activity Duplication)			
1) PHYSICAL EDUCATION			
Programs	37	37	38
Total Registrations	6,521	6,098	6,134
(Undergrad)	(5,384)	(5,190)	(5,156)
(Grad)	(827)	(633)	(708)
(Staff)	(310)	(275)	(270)
2) INTRAMURALS (M/W & COED)			
Programs	29	27	28
Teams	1,229	1,151	1,294
Students	11,876	10,857	12,031
3) CLUBS			
Programs	30	29	25
Students	763	740	589
4) INTERCOLLEGIATES			
Women's Programs	11	11	10
- Student Participants	195	189	233
- Letter Awards:	119	143	145
(Varsity)	(96)	(95)	(94)
(Jr. Varsity)	(8)	(29)	(31)
(Frosh)	(15)	(19)	(20)
Men's Programs	21	21	21
- Student Participants	609	645	623
- Letter Awards:	461	457	475
(Varsity)	(259)	(271)	(259)
(Jr. Varsity)	(136)	(137)	(142)
(Frosh)	(66)	(49)	(74)

EXHIBIT II

PHYSICAL EDUCATION REGISTRATIONS 1982-83
(IN ORDER OF REGISTRATION PARTICIPATION)

Dance		684
Partner Dance	223	
Beg. Ballet or (I)	108	
Jazz	102	
Int. Ballet or (II)	84	
Ballet II-III	74	
Tap Dance	59	
Move. for Body Cond.	34	
TOTAL DANCE	684	
Body Development (Wgt. Rm.)		527
Self-Designed Fitness		466
Tennis		403
Beginning	214	
Intermediate	189	
TOTAL TENNIS	403	
Sailing		396
Swimming		369
Beginning	182	
Advanced Beginning	48	
Advanced Techniques	48	
Intermediate	47	
Red Cross W.S.I.	32	
Advanced Life Saving	12	
TOTAL SWIMMING	369	
Skating		349
Beginning	319	
Figure Skating	30	
TOTAL SKATING	349	
Pistol		325
Squash		213
Volleyball		200
Fencing		191
Archery		182
Precision Air Rifle		125
Sculling		124
Golf		106
Badminton		105
Small Bore Rifle		94
T'ai Chi		91
Basketball Fundamentals		90
Lacrosse		84
Softball		80
Hockey		80
Judo		63
Rock Climbing		55
Karate		54
CPR		53
Touch Football		51
Ultimate Frisbee		44
Yoga		43
Scuba		42
First Aid		32
Table Tennis		32
Skin Diving		19
Rugby		17
Personal Health Fitness		17
Diving		15
Bicycling		13
		5,834
Independent Activities Period		687
TOTAL		6,521

EXHIBIT III

CLUB PROGRAMS

	1980-81	1981-82	1982-83
(2) Aikido	--	15	17
Archery	11	11	12
Badminton	16	20	27
(2) Bowling	--	11	12
Cheerleading	12	12	11
Cricket	23	24	26
Fencing	24	25	30
Figure Skating	23	55	50
Football	47	45	48
Folk Dance	35	40	33
(1) Frisbee	40	60	53
Hockey, Men	26	25	24
(1) Hockey, Women	24	26	27
(2) Ice Dance	--	30	34
Judo	10	--	6
Karate, Shotokan	24	30	26
(2) Lacrosse	--	12	23
Rifle & Pistol	45	45	40
Rugby, Men	45	47	44
Rugby, Women	15	17	18
Scuba	26	25	26
(1) Society for Creative Anachronism	14	20	19
Soccer, Grad Men	20	24	28
(3) Soccer, Women	--	--	30
Square Dance	22	--	14
Table Tennis	16	14	20
Tae Kwon-Do	22	24	22
Volleyball, Men	15	20	24
Water Polo, Women	14	13	14
White Water	20	20	22
(2) Wu-Tang Boston	--	15	15
(2) Wu-Tang MIT	--	15	17
TOTAL PARTICIPANTS	589	740	812
TOTAL PROGRAMS	25	29	32

(1) New Clubs 1980-81

(2) New Clubs 1981-82

(3) New Clubs 1982-83

EXHIBIT IV

INTRAMURAL PARTICIPATION

	1982-83		1981-82		1980-81	
	Teams	Approx. No. Part.	Teams	Approx. No. Part.	Teams	Approx. No. Part.
Backgammon	39	176	43	194	56	252
Badminton	43	215	52	124	46	230
Basketball	134	1072	138	1104	156	1248
Bowling	75	225	108	124	110	330
Chess	Inactive		12	72	15	90
Cross Country	4	45	4	35	9	90
Cycling	3	29	9	40	16	70
Fencing	7	48	9	41	8	42
Football	84	1260	80	1200	85	1275
Frisbee	46	460	53	530	37	370
Fussball	21	126	Inactive		Inactive	
Hockey	80	960	78	936	67	804
Octathon	18	234	16	192	20	248
Pentathlon	6	90	6	90	5	75
Pool & Billiards	20	100	30	150	21	105
Rifle	Inactive		Inactive		29	135
Rugby Sevens	16	144	8	72	Inactive	
Sailing	8	32	12	48	10	40
Soccer	88	1496	84	1428	87	1479
Softball	148	2072	160	2240	164	2296
Squash	54	270	32	160	41	205
Swimming	6	75	8	81	13	92
Table Tennis	56	392	Inactive		77	539
Team Tennis	32	144	Inactive		Inactive	
Tennis		128	9	140		128
Track, Indoor	9	86		110	11	93
Track, Outdoor	6	64		38	9	52
Volleyball	166	1328	144	1152	136	1088
Water Polo	46	460	42	420	51	510
Weight Lifting	5	51	3	24	6	57
Wrestling	9	94	11	112	9	88
TOTALS	29 Programs		27 Programs		28 Programs	
	1,229 Teams		1,151 Teams		1,294 Teams	
	11,876 Participations		10,857 Participations		12,031 Participations	

EXHIBIT V

MIT INTERCOLLEGIATE ATHLETIC COMPETITION 1982-83

MEN'S SPORTS (19) (vs. Actual 21)*

1982 FALL	WON	LOST	TIED
Cross Country	4	3	
Golf +	6	0	
Soccer	3	10	
Water Polo	14	8	1
1982-83 WINTER	**WON**	**LOST**	**TIED**
Basketball	6	16	
Fencing	8	8	
Gymnastics	5	6	
Pistol	7	2	
Rifle	30	0	
Squash	3	16	
Swimming	5	3	
Track, Indoor	3	4	
Wrestling	11	8	
1983 SPRING	**WON**	**LOST**	**TIED**
Baseball	9	11	
Crew, Heavyweight	0	7	
Crew, Lightweight	5	1	
Golf +	10	0	
Lacrosse	6	6	
Tennis	6	5	
Track, Outdoor	3	1	
1982-83 TOTALS	144 (.556)	115	1
1981-82 TOTALS	129 (.481)	139	3

*No won-lost record for Men's Sailing, Skiing

+ Golf plays combined fall/spring schedule

WOMEN'S SPORTS (10) (vs. Actual 11)**

1982 FALL	WON	LOST	TIED
Cross Country	11	0	
Field Hockey	5	9	
Tennis ++	5	6	
Volleyball	34	5	
1982-83 WINTER	**WON**	**LOST**	**TIED**
Basketball	9	10	
Fencing	13	6	
Gymnastics	3	6	
Swimming	4	5	
1983 SPRING	**WON**	**LOST**	**TIED**
Crew	2	6	
Softball	11	6	
Tennis ++	1	3	
1982-83 TOTALS	98	62 (.613)	
1981-82 TOTALS	71	90 (.441)	

**No won-lost record for Women's Sailing

++ Women's Tennis plays combined fall/spring schedule

1982-83 CLUB VARSITY SPORTS

	WON	LOST
Football	3	5
Ice Hockey	11	4

EXHIBIT VI

MEN'S INTERCOLLEGIATE ATHLETICS - INDIVIDUAL ACHIEVEMENTS 1982-83

Straight 'T' Award Winners

BASKETBALL

Mark Branch III, Class of 1983 (Raleigh, N.C.) - Named to the Eastern College Athletic Conference New England Division III All-Star team.

Robert L. Joseph, Class of 1983 (Pensacola, Fla.) - Received an honorable mention on the College Sports Information Directors of America (CoSIDA) College Division Academic all-America team.

FENCING

Russell D. Holtz, Class of 1984 (Tulsa, Okla.) - Won the foil title at the Intercollegiate Fencing Association Championships.

PISTOL

Joseph J. Mayo, Class of 1983 (Phoenix, Ariz.) - Received all-America recognition in air and free pistol. Repeat winner.

David W. Martin, Class of 1984 (Melrose, Ma.) - Received all-America recognition in standard pistol. Repeat winner.

VARSITY SAILING

Peter A. Quigley, Class of 1984 (Larchmont, N.Y.) - Divisional winner at the New England Championships.

SOCCER

John D. Busa, Class of 1983 (Needham, Ma.) - Named to the Greater Boston League all-star team for the fourth consecutive year.

SWIMMING

Andrew A. Renshaw, Class of 1985 (McKownville, N.Y.) - Finished third in the 100-yard butterfly and sixth in the 200-yard butterfly at the NCAA Division III Championships to receive all-America recognition.

Robert W. Schoenlein, Class of 1984 (Petaluma, Ca.) - Finished 10th in the 100-yard breaststroke and 11th in the 200-yard breaststroke at the NCAA Division III Championships to receive all-America recognition for the third straight year. Repeat winner.

OUTDOOR TRACK

Patrice M. Parris, Class of 1985 (Georgetown, Guayana) - Finished fifth in the hammer throw at the NCAA Division III Championships to receive all-America recognition.

WATER POLO

John T. Friedman, Class of 1983 (Belvedere, Ca.) - Named to the first-team Division III all-America team. Repeat winner.

WRESTLING

Kenneth R. Shull, Class of 1984 (Cogan Station, Pa.) - Finished seventh at 134 pounds at the NCAA Division III Championships to receive all-America recognition; New England Division III champion at 134 pounds for second consecutive year. Repeat winner.

Timothy P. Skelton, Class of 1985 (Manitowoc, Wis.) - New England Division III champion at 126 pounds.

ATHLETIC AWARDS CONVOCATION WINNERS

The Class of 1948 Award is presented annually to the male senior athlete of the year.

Mark Branch III, Class of 1983, was a four-year starter on the men's basketball team. The 5-10 guard was named to the Eastern College Athletic Conference (ECAC) New England Division III all-star team. He also received the Division III Academic Award from the New England Basketball Coaches Association for outstanding athletic and academic achievements. Branch led MIT in scoring this past season with a 17.1 average and finished his outstanding career by scoring 1,441 points, fourth best in MIT history.

The Admiral Edward L. Cochrane Award is given annually to a male senior who has shown highest qualities of humility, leadership, and scholarship in intercollegiate athletics.

John D. Busa, Class of 1983, was a four-year starter on the soccer team. He was named to the Greater Boston League all-star team for the fourth consecutive year to become the first MIT player to accomplish such a feat.

The Malcolm G. Kispert Awards are presented annually to the male and female senior scholar/athlete of the year.

John S. Schmitz, Class of 1983, was a member of the swimming team.

The Burton R. Anderson, Jr. Awards are presented to the outstanding manager of the year for a men's and women's intercollegiate team.

Erik R. Altman, Class of 1983, was the track manager for four years. He previously won the Anderson Award in 1980.

The Varsity Club Award is given to the outstanding freshman athlete.

Craig N. Poole, Class of 1986, was a member of the basketball and baseball teams.

OTHER INDIVIDUAL HIGHLIGHTS

Baseball - Steven A. Kosowsky, Class of 1983 (Newton, Ma.) was named to the Greater Boston League all-star team for the second straight year.

Crew (Heavyweight) - Ronald G. Wilkes, Class of 1984 (Little Rock, Ark.) and Andrew G. Ziegler, Class of 1985 (Menlo Park, Ca.) won the 1983 Intercollegiate Rowing Association National Championship Varsity Pair-oared without Coxswain race in Syracuse, N.Y.

Crew (Lightweight) - Kim A. Marvin, Class of 1985 (Denton, Md.) was named to the United States lightweight four without coxswain team which will compete in the World Championships Aug. 26-Sept. 4 in Dusseldorf, West Germany.

Club Varsity Football - Douglas R. Gouchoe, Class of 1983 (Concord, N.H.) was selected to the National Collegiate Football Association second-team all-America squad as a defensive halfback. Gouchoe also was selected to the New England Conference first team.

Club Varsity Football - Scott A. Berceli, Class of 1985 (Pittsburgh, Pa.) was named to the New England Conference second team at offensive guard.

Club Varsity Football - John K. Einhorn, Class of 1984 (San Jose, Ca.) was named to the New England Conference second team at offensive tackle.

Club Varsity Football - Jon E. Opakski, Class of 1984 (Clinton, Md.) was named to the New England Conference second team at linebacker.

Cross Country/Track - Robert M. Walmsley, Class of 1984 (Cheshire, England) finished fourth among 113 runners at the 74th Annual Intercollegiate Association of Amateur Athletes of America (IC4A) Cross Country Championships held in Boston. He also won the 10,000-meter run at the New England Division III Outdoor Track & Field Championships held at MIT.

Fencing - Russell D. Holtz, Class of 1984 (Tulsa, Okla.) in foil, David A. Humphreys, Class of 1982 (Falls Church, Va.) in epee, and Bradley A. Nager, Class of 1983 (New York, N.Y.) in sabre, competed in the NCAA Championships in Kenosha, Wis.

Gymnastics - Linus J. Kelly, Class of 1982 (East Weymouth, Ma.), David A. Roberts, Class of 1985 (Dayton, Ohio), and Michael S. Ehrlich, Class of 1984 (Wilmette, Ill.) competed in the NCAA Division II Championships in Davis, Ca.

Lacrosse - William T. Larkins, Class of 1984 (West Hartford, Ct.) finished fifth nationally among Division III goalies in save percentage (.706). He also received an honorable mention on the Snively Division all-star team.

Lacrosse - Mark J. Brine, Class of 1985 (New Haven, Ct.) received an honorable mention on the Snively Division all-star team.

Lacrosse - Michael J. Ambrogi, Class of 1985 (Corning, N.Y.) received an honorable mention on the Snively Division all-star team.

Lacrosse - John M. (Mark) Johnston, Class of 1984 (Rye, N.Y.) received an honorable mention on the Snively Division all-star team.

Lacrosse - Harry J. Lipschitz, Class of 1982 (Bellmore, N.Y.) received an honorable mention on the Snively Division all-star team.

Pistol - Duncan Hughes, Class of 1984 (Albany, Ca.) finished seventh in individual air pistol at the national championships.

Rifle - Clifford J. Eskey, Class of 1985 (Bethesda, Md.) competed in the NCAA Championships for the second straight year finishing 11th in smallbore competition. He also was selected to the New England College Rifle League all-star team and had the high average in league competition.

Rifle - Gregory P. Buliavac, Class of 1983 (Portland, Ore.) was named to the New England College Rifle League all-star team.

Sailing - Bruce F. Klein, Class of 1983 (Sea Cliff, N.Y.), Peter A. Quigley, Class of 1984 (Larchmont, N.Y.), Albert H. Pleus, Class of 1984 (Plandome, N.Y.), Lars E. Rosenblad, Class of 1984 (Monmouth Hills, N.J.), Stephen J. Paradis, Class of 1985 (Andover, Ma.), and John E. York, Class of 1983 (Cataumet, Ma.) competed in the national championships in Corpus Christi, Tex.

Swimming - John S. Schmitz, Class of 1983 (San Rafael, Ca.) named to the CoSIDA College Division Academic all-America first team.

Tennis - Ramy S. Rizk, Class of 1986 (Westfield, N.J.) won the "B" singles title at the New England Championships (College Division) held at Springfield College.

Tennis - George Hoehn, Class of 1983 (O'Fallon, Ill.) won the "C" division singles title at the New England Championships (College Division) held at Springfield College.

Track (Indoor & Outdoor) - Patrice M. Parris, Class of 1985 (Georgetown, Guayana) won the 35-lb. weight throw at the New England Division III Indoor Track & Field Championships held in New London, Ct. He also won the hammer throw at the New England Division III Outdoor Track & Field Championships held at MIT.

Track (Indoor) - Joseph F. Presing, Class of 1984 (Westwood, N.J.) won the 60-yard hurdles at the New England Division III Indoor Track & Field Championships.

Track (Indoor) - David M. Richards, Class of 1986 (E. Greenwich, R.I.) won the 600-yard run at the New England Division III Indoor Track & Field Championships.

Water Polo - John T. Friedman, Class of 1983 (Belvedere, Ca.) won a $2,000 scholarship for graduate study from the NCAA. Named to the CoSIDA College Division Academic all-America first-team.

Wrestling - Stephen C. Ikeda, Class of 1985 (Valparaiso, Ind.) finished second (142 points) at the New England Division III Championships in New London, Ct. and competed in the NCAA Division III Championships in Wheaton, Ill.

Wrestling - Kenneth R. Shull, Class of 1984 (Cogan Station, Pa.) named to the CoSIDA College Division Academic all-America first-team.

EXHIBIT VII

MEN'S INTERCOLLEGIATE ATHLETICS - TEAM ACHIEVEMENTS 1982-83

Basketball - Won the 1983 Schoenfeld Sportsmanship Award presented by the Collegiate Basketball Officials Association. The award goes to the Eastern College Athletic Conference team which, in the opinion of the CBOA, shows the highest degree of ethics and sportsmanship in the conduct of its basketball games. More than 225 schools in the East are eligible for the award.

Crew (Lightweight) - Finished with an impressive 5-1 record and won the Biglin Cup over Harvard and Dartmouth for the second time in four years. At the Eastern Sprints, MIT finished fifth in the grand finals and fifth among 10 teams in the Jope Cup standings (points in Eastern competition).

Cross Country - Posted a 4-3 record for its fifth straight winning season and competed in the NCAA Division III Championships for the fourth consecutive year.

Golf - Finished its combined fall/spring season with a perfect 16-0 record for first unbeaten season ever. Since 1973, the team has a remarkable 116-63-3 record.

Ice Hockey - Continued its winning ways with an 11-4 record for its third straight winning season (36-12 since 1981).

Pistol - Finished second in air pistol, third in free pistol, and fifth in standard pistol at the national championships.

Rifle - Compiled a perfect 30-0 record in winning the New England College Rifle League. Also placed first among five teams at the NCAA Sectional.

Sailing - Competed in the national championships finishing 11th.

Tennis - Finished with a 6-5 record and placed second among 27 teams at the New England College Division Championships.

Track (Outdoor) - Finished with a 3-1 record and won its third consecutive New England Division III championship.

Wrestling - Finished with an 11-8 record for its third straight winning season and finished second among nine teams at the Northern New England Championships and fifth among 14 schools at the New England Division III championships.

EXHIBIT VIII

WOMEN'S INTERCOLLEGIATE ATHLETICS - INDIVIDUAL ACHIEVEMENTS 1982-83

Straight 'T' Award Winners

FENCING

Ya-Pei A. Chang, Class of 1983 (Seattle, Wash.) - Won the gold medal finishing first at the New England Championships.

SWIMMING

Lori A. Blackwelder, Class of 1986 (Cincinnati, Ohio) - Finished second in the 3-meter diving and 11th in the 1-meter diving events at the New England Championships.

Marie H. Issa, Class of 1986 (Binghamton, N.Y.) - Finished 10th in the 50-yard butterfly at the NCAA Division III Championships.

VOLLEYBALL

MIT advanced to the Eastern regional final of the NCAA Division III Tournament, won the Eastern Association for Intercollegiate Athletics for Women (EAIAW) Division III Northeast Tournament, won the Massachusetts AIAW "Class A Division" Tournament, and finished with a 34-5 record for its best mark in eight years of varsity competition. Team members receiving the Straight "T": Margaret L. Kniffin, Class of 1983 (Maplewood, N.J.); Damaris Ayuso, Class of 1984 (Guaynabo, Puerto Rico);

Michelle M. Heng, Class of 1984 (Lincoln, Neb.); Akiko Kodaka, Class of 1984 (Closter, N.J.); Amy B. Smith, Class of 1984 (Lexington, Ma.); Barbara E. Wesslund, Class of 1984 (St. Paul, Minn.); Lori A. Cantu, Class of 1985 (San Antonio, Tex.); Janette M. Kauth, Class of 1985 (Columbus, Ohio); Julie A. Koster, Class of 1985 (Santa Ana, Ca.); Anella E. Munro, Class of 1985 (Vancouver, British Columbia, Canada); Mary L. Petrofsky, Class of 1985 (San Rafael, Ca.); Jennifer A. Smith, Class of 1986 (Georgetown, Ontario, Canada), and Susan J. Wittman, Class of 1986 (Rochester, N.Y.). Heng, Cantu, Jennifer Smith and Wittman are first-time winners.

ATHLETIC AWARDS CONVOCATION WINNERS

The Betsy Schumacker Award for excellence in athletic competition by an undergraduate woman.

Anella E. Munro, Class of 1985, was named to the National Collegiate Athletic Association (NCAA) Division III Eastern regional all-star team after leading MIT to the quarterfinals of the national tournament. She also was named to the Eastern AIAW Division III Northeast all-star team after helping MIT win the team title in that tournament. Munro, a two-year starter, was among the top performers at MIT posted a 34-5 record this past season, the team's best mark in eight years of competition. MIT also won its fifth state tournament crown in eight years.

The Pewter Bowl Award is given annually to a female senior who has shown highest qualities of inspiration and leadership in contributing to women's athletics

Theresa A. Sutton, Class of 1983, was co-captain and the most valuable performer on the women's cross country team which posted a perfect 11-0 record last fall. Sutton played a key role in the development and creation of women's cross country as an intercollegiate varsity sport at MIT in 1981.

The Malcolm G. Kispert Awards are presented annually to the male and female senior scholar athletes of the year.

Margaret L. Kniffin, Class of 1983, a member of the women's volleyball team.

OTHER INDIVIDUAL HIGHLIGHTS

Joyce M. Kelly, Class of 1983 (Winthrop, Ma.) served as co-captain of the women's basketball team. She was a four-year starter and received a most valuable player award for the third straight season.

Laura L. Kiessling, Class of 1983 (Lake Mills, Wis.), Ruth M. Fricker, Class of 1985 (Lexington, Ma.), Elizabeth Bradley, Class of 1983 (Cliffside Park, N.J.), Lillian M. Hill, Class of 1983 (Piedmont, Ca.), and Linda E. Mar, Class of 1985 (Providence, R.I.) finished third behind Northeastern and Radcliffe in the women's varsity four race at the National Women's Rowing Championships in Madison, Wis.

Louise Jandura, Class of 1984 (Clifton, N.J.) was named to the 1983 College Sports Information Directors of America (CoSIDA) College Division Women's Softball Academic all-America first team. She is the first MIT woman to receive a berth on an Academic all-America squad.

Pamela C. Sullivan, Class of 1986 (Dover, N.H.) was named to the New England College Rifle League all-star team.

Linda M. Maxwell, Class of 1985 (San Ramon, Ca.) and Jean Fitzmaurice, Class of 1986 (Burlington, Ma.) competed in the national sailing championships in Corpus Christi, Tex.

WOMEN'S INTERCOLLEGIATE ATHLETICS - TEAM ACHIEVEMENTS 1982-83

Basketball - Posted a 9-10 record which was the most wins in a season in seven years.

Cross Country - Only in its second year of varsity competition, team finished with a perfect 11-0 record and competed in three post-season championships.

Fencing - Finished with an impressive 13-8 record against strong competition, won the New England Championships, and placed fifth at the NCAA Northeast Regional Tournament.

Softball - Posted a fine 11-6 record which tied a school record for most wins in a season and participated in both the Massachusetts and Eastern AIAW Division III Tournament.

Volleyball - Compiled an enviable 34-5 record which was the team's best mark in eight years of varsity competition. Advanced to the NCAA Division III Eastern regional final, won the Eastern AIAW Division III Northeast tournament, and captured its fifth state tournament title in the last eight years.

EXHIBIT IX

MIT STUDENT WINNERS OF NCAA POSTGRADUATE SCHOLARSHIPS

Year of Award	Sport	Name of Senior Winner
1966	Basketball	John Michael Mazola
1967	Basketball	Robert Miller Hardt
1968	Basketball	David Guild Jansson
1971	Basketball	Bruce Christopher Wheeler
1977	Track/Cross Country	Frank Charles Richardson
1978	Fencing	Mark J.T. Smith
1979	Swimming	Preston Vorlicek
1982	Swimming	*Karen Marie Klincewicz
1983	Water Polo	John Thomas Friedman

*First Woman Winner in MIT History

EXHIBIT X

MAJOR TOURNAMENTS AT MIT 1982-83 (CLUB & INTERCOLLEGIATE)

Indoor

Women's Volleyball - opening round game of the NCAA Division III Women's Volleyball Championships, Friday, November 19, 1982

Water Polo - New England Championships, November 6-7, 1982

Rifle - New England College Rifle League finals, February 26, 1983

Wrestling - Holiday Wrestling Tournament, du Pont Gymnasium, Sunday, January 2, 1983

Table Tennis Club Tournament - Sunday, January 16, 1983

Men's Volleyball Club Tournaments - March 6, April 2 & 3, April 17, 1983

China Study Group Table Tennis Tournament - Saturday, March 26, 1983

Figure Skating Club Exhibitions - January 21, March 9, March 12, 1983

China Study Group Badminton Tournament - July 22, 1983

Outdoor

Women's Sailing - Single-Handed Championships, October 2-3, 1982

Soccer - New England Intercollegiate Soccer League All-Star Game, November 21, 1982

Women's Softball - Massachusetts AIAW Tournament "Class 'C'", April 22, 1983

Outdoor Track - New England Division III Outdoor Track & Field Championships, May 7, 1983

Women's Tennis - Eastern AIAW Division III Championships, May 7, 1983

EXHIBIT XI

GREATER BOSTON COMMUNITY USAGE OF MIT FACILITIES
1982-83

Alumni Pool

Master's Swim Meet
Moray Wheels (Disabled Scuba Divers)
Alpha Phi Omega (Cambridge Scouts)
MIT/Wellesley Upward Bound - Pool Courtyard Only

Briggs Field

Just-A-Start Program
Middlesex Courthouse Softball League
Boston University Hammer Throwers
Boston University Football
Cambridge Boys Club

du Pont Gymnasium

Walter Sullivan Party
Committee of Elders Christmas Party
SAElor Party (for Muscular Dystrophy)
Volunteers for Youth Christmas Party
Tech Model Aircrafters
Holiday Wrestling Tournament

MIT Athletics Center

Mass. State Science Fair
Liberty Athletic Club Women's Track Clinic
N.E.I.S.L. All-Star Game
Fall Classis Road Race
N.E. Athletic Conference
Winchester High School
State Architect's Exam
Cambridge Boys Club
Lambda Chi Alpha-Club Amherst American Diabetes Race
M.D.C. Police

Pierce Boathouse

U.S. Rowing Team
Olympic Rowing Committee
International Liaison Program

Rockwell Cage

Boston School for the Deaf (N.E. Volleyball Tournament for the Deaf)
Mass. Juniors Volleyball
Prep School Wrestling Championships
Senator LoPresti Softball Team
N.E. Jr. Volleyball Championships

Steinbrenner Stadium

Volunteers for Youth Track and Field Day
Cambridge Public Schools (Football)
N.E. Athletics Congress (Racewalking)
Mass. State Police Junior Olympic Track Meet
N.E.I.S.L. All-Star Game
Mt. St. Joseph's Girls Track Team
Farr Academy
Cambridge Rindge & Latin High School
Mario Umana High School
Cambridge Police Academy
Cambridge Boys Club
Conventures Kendall Classic Race
Harvard Track Team
Alternative Schools Track Meet

Tennis Courts

E.A.I.A.W. Tennis Tournament
Boston University Tennis Team

Varsity Club Lounge

Committee of Elders Christmas Party
Volunteers for Youth Christmas Party

EXHIBIT XII

ATHLETIC CARD SALES

	1982-83	1981-82
Students	6,234	6,913
Faculty	386	424
Staff	1,548	1,822
Family	470	499
Draper Lab	235	220
Alumni	385	416
TOTAL	9,258	10,294

SAILING PROGRAM PARTICIPATION

	Calendar 1982		Calendar 1981	
Total Students		1,300		1,436
- Card Sales	925		1,025	
- Phys. Ed. Classes	375		411	
Faculty/Staff		193		220
Alumni		93		91
Special Family		147		197
TOTAL		1,733		1,944

MIT Press

1982-83 was a year of adjustment, growth, and new ventures; a year which witnessed the continuing definition of the direction of our publishing programs, a distinguished new list, new efficiency in our operations, and a significant improvement in our financial position.

We published 127 books; 92 of these were original publications and 35 were paperbacks reprinted from our own hardcover backlist; 13 of the original publications were published simultaneously in hardcover and paperback; and six titles were original paperbacks. *Abusing Science: The Case Against Creationism* by Philip Kitcher was our overall best seller at 7,000 copies. Other best sellers were *Some Concepts and Consequences of the Theory of Government and Binding* by Noam Chomsky; *The Mental Representation of Grammatical Relations* edited by Joan Bresnan; *Robot Motion: Planning and Control* edited by J. Michael Brady et al.; *Banking on the Poor: The World Bank and World Poverty* by Robert L. Ayres; *Earthfire: The Eruption of Mt. St. Helens* by Charles Rosenfeld and Robert Cooke; *Genetic Alchemy: The Social History of the Recombinant DNA Controversy* by Sheldon Krimsky; *American Design Ethic: A History of Industrial Design* by Arthur J. Pulos; *Robot Manipulators: Mathematics, Programming, and Control* by Richard P. Paul; *Crystals and Crystal Growing* by Alan Holden and Phylis Morrison; and *Technology in America: A History of Individuals and Ideas* by Carroll W. Pursell. A total of 420,441 copies of our books was sold for net sales of $4,919,000.

We completed our review of program plans, in collaboration with our editorial and management boards, aimed at the development of depth and focus in our lists in architecture and design arts; linguistics, artificial intelligence, and cognitive science; economics; electrical engineering and computer science; applied mathematics and physics; and philosophy. Approximately 85 percent of our publishing program will fall within these categories during the next three years. We are currently exploring the development of other publishing programs in the sciences, and prospects for publication of databases and software.

We continued to expand our use of microcomputers and word processors throughout the Press this past year. Computergraphics, our computer-based typesetting system, produced approximately 10,000 pages of type in its first full year of operations. Production schedules for projects produced on the system were significantly better than schedules for projects that were produced traditionally. In addition, we had our first hands-on experience with manuscripts delivered in disk or tape form, which were then converted for use on our Penta system; we had several opportunities to input and edit electronically. Decmate word processors and Apple and IBM personal computers were incorporated into the Journals division, and into our Acquisition and Marketing departments. Future plans include linking our editorial and design departments to Computergraphics, expanding our capability to receive electronic copy of manuscripts and employing the underutilized capacity of Computergraphics to take on Institute work. We are also currently exploring software and database development and distribution and how we can support and interact with Project Athena.

Financial results were better than planned and significantly better than fiscal year 1982. Sales were up 8.5 percent over last year and operating expenses were kept flat, largely through a 10 percent reduction in staff and tight operating budgets. Our operating statement reported a deficit of $50K for this fiscal year, which compared favorably with our forecasted deficit of $157K, and last fiscal year's deficit of $399K. We produced a net positive cash flow of $172K, which contributed to reducing our working capital debt to its lowest level in a decade, measured in constant dollars.

These results were produced not by a single event but through the concentrated efforts the The MIT Press staff and the execution of a plan designed to respond to the conditions that produced such generally depressed sales throughout the industry. Changes instituted last year will continue to benefit operations in the future.

The Journals division continued to expand, showing a significant profit for the second year in a row. Journal sales for this fiscal year increased by 11 percent and produced a net from operations of $202K, an increase of 40 percent over last fiscal year. The Press publishes 12 journals and 3 annuals. An additional 3 journals were acquired last year which will see their first full year of publication in fiscal year 1984. The MIT Press Bookstore exceeded expectations once again.

COMPARATIVE OPERATING DATA

(in thousands)

	Fiscal Year 1983	Fiscal Year 1982
	Actual	Actual
Total Net Sales	4,919	4,535
Cost of Sales	2,233	2,154
Gross Margin	2,686	2,381
Other Income	28	35
Total Income	2,714	2,416
Operating Expenses	2,978	2,953
Interest Charges	9	8
Net Books Division	(273)	(545)
Bookstore	21	
Journals Surplus	202	146
NET	(50)	(399)

The Press continued to win wide recognition for its books. In addition to numerous design awards, the American Bar Association awarded the Press an American Bar Association Certificate of Merit for *A Primer on American Labor Law* by William B. Gould, "in recognition of a noteworthy contribution to public understanding of the American system of law and justice;" and the Geographic Society of Chicago's Medals and Awards Committee selected *The Human Impact: Man's Role in Environmental Change* by Andrew Goudie to be among those receiving one of their 1982 Publication Awards.

The Press received several grants over this past year: The Andrew W. Mellon Foundation awarded the Press a grant of $75,000 to subsidize the publication of books in fields of the humanities, particularly scholars' first or second books, and to encourage the adoption of more productive electronic technologies; the Italian Ministry awarded a $1,500 grant toward the translation of Paolo Maffei's "L'Universo Nel Tempo;" the Sloan Foundation awarded a grant of $12,000 for publication of a volume of selected essays of Arthur Okun; The Japan Foundation awarded the Press a grant of $2,737 toward the translation of *Visual and Spacial Structure of Landscapes* by Tadahiko Higuchi; and the National Endowment for the Humanities awarded the Press a $5,200 grant toward publication of *The Legitimacy of the Modern Age* by Hans Blumenberg. We received support from several sources for "Pictorial History of Chinese Architecture," to be edited by Wilma Fairbank, including a grant from the Xerox Corporation for $10,000.

Faculty serving on The MIT Press editorial board in 1982-83 were Professors Suzanne Berger, Peter Elias, Robert L. Jaffe, Carl Kaysen, John Ploeger Longwell, Leo Marx, Daniel N. Osherson, William L. Porter, and Frank Solomon. Jay Lucker, Constantine B. Simonides, and Frank Urbanowski served as ex-officio members. Professor Ascher Shapiro served as chairman of the editorial board.

The MIT Press management board met twice during the year. Members of the board are John M. Deutch, Dean, School of Science; Ann F. Friedlaender, Head of the Department of Economics; Jeremiah Kaplan, President, MacMillan Publishing Co., Inc.; Norman Pomerance, Vice President, General Books Group, Harper & Row; Alvin J. Silk, Associate Dean of the Sloan School; W. Bradford Wiley, Chairman, John Wiley & Sons, Inc.; and Jack Schulman, former Director of the Cambridge University Press. Professor Shapiro, chairman of the editorial board, and Mr. Urbanowski, director of The MIT Press, are ex-officio members. Mr. Simonides, vice president in the Office of the President, is chairman of the management board.

BOOK PROGRAM

Outstanding scholarly and professional books published this year were: *Problem Book in Phonology: A Workbook for Introductory Courses in Linguistics and Modern Phonology* by Morris Halle and Richard Clements; *Modularity of Mind* by Jerry A. Fodor; *Situations and Attitudes* by Jon Barwise and John Perry; *The Logic of Perception* by Irwin Rock; *Quine and Analytic Philosophy* by George Romanos; *Physics as Natural Philosophy: Essays in Honor of Laszlo Tisza*, edited by Abner Shimony and Lucien Goldman; *Asymptotic Realms of Physics: Essays in Honor of Francis Low*, edited by Alan H. Guth, Kerson Huang, and Robert L. Jaffe; *Game Theory in the Social Sciences: Concepts and Solutions* by Martin Shubik; *Fusion: Science, Politics, and the Invention of a New Energy Source* by Joan Lisa Bromberg; *An Introduction to Risk and Return From Common Stocks*, Second Edition, by Richard A. Brealey; *Money and Inflation* by Frank Hahn; *Folded, Spindled and Mutilated: Economic Analysis and U.S. v. IBM* by Franklin M. Fisher et al.; *Creationism, Science, and the Law*, and *Quality in Science*, both derived from the journal *Science, Technology and Human Values*, and edited by Marcel La Follette; *In Search of Modern Architecture: A Tribute to Henry-Russell Hitchcock* edited by Helen Searing; *Arcades: The History of a Building Type* by Johann F. Geist; *The Aesthetic Townscape* by Yoshinobu Ashihara; and *The American Blood Supply: Issues*

and Policies of Blood Donation by Alvin W. Drake, Stan N. Finkelstein, and Harvey M. Sapolsky.

Among the outstanding trade books published this year were: *How Life Learned to Live: Adaptation in Nature* and *When the Snakes Awake: Animals and Earthquake Prediction*, both by Helmut Tributsch; *H. H. Richardson: Complete Architectural Works* by Jeffrey Karl Ochsner; *The De Stijl Environment* by Nancy J. Troy; *Los Ambulantes: The Itinerant Photographers of Guatemala* by Ann Parker and Avon Neal; *Getting Up: Subway Graffiti in New York* by Craig Castleman; *and Before Mickey: The Animated Film, 1898-1928* by Donald Crafton.

The Press published two new reference works, *The Aquarium Encyclopedia*, edited by Gunther Sterba; and *Who's Who in Economics: A Biographical Dictionary of Major Economists, 1700-1981*, edited by Mark Blaug and Paul Sturges.

Series continued to play an important role in program development. Three new series were established: the American Monograph Series, published in collaboration with the Architectural History Foundation, is designed to focus attention on American architects who do not necessarily belong to the established canon but have contributed significantly to America's architectural heritage; Bradford Books signed a major new series in developmental psychology, Learning, Development and Conceptual Change, edited by Lila Gleitman, Susan Carey, Elizabeth Spelke, and Elissa Newport; and the Series in History of Computer Science was established, edited by Peter Denning. Initial planning was put into place for a major series in Computational Models in Cognition and Perception, to compliment our existing series in Artificial Intelligence.

The ACM Doctoral Dissertation Series was launched with the publication of the first book: *Area-Efficient VLSI Computation* by Charles E. Leiserson. The ACM Distinguished Dissertation Series was launched with publication of three books: *Abstraction Mechanisms and Language Design* by Paul Halfinger, *Algorithmic Program Debugging*, Ethud Y. Shapiro, and *Formal Specification of Interactive Graphics Programming Languages* by William R. Mallgran. The fourth and fifth books in the Opposition Books Series were published: *Style and Epoch* by Moisei Ginzburg, and *Spoken into the Void: Collected Essays by Adolf Loos, 1897-1900*, edited by Adolf Loos et al. Three new books were published in Studies in Contemporary German Social Thought: *Against Epistemology: A Metacritique, Studies in Husserl and the Phenomenological Antinomies* by Theodor W. Adorno; *The Legitimacy of the Modern Age* by Hans Blumenberg; and *Philosophical-Political Profiles* by Jorgen Habermas.

MIT Press series editors are Patrick Henry Winston and John Michael Brady (Artificial Intelligence); Samuel Jay Keyser (Current Studies in Linguistics, Cognitive Theory, and Mental Representation; Linguistic Inquiry Monographs); Jay W. Forrester (MIT Press/Wright Allen Series in System Dynamics); Alan S. Willsky (Signal Processing, Optimization, and Control); Marvin L. Manheim (Transportation Studies); Hilary M. Irvine (Cable Structures); Jeffrey Harris (Health and Public Policy); Michael Folsom (Documents in American Industrial History); Thomas McCarthy (Studies in Contemporary German Social Thought); John van Maanen (Organizational Studies); Richard Schmalensee (Regulation of Economic Activity); S. J. Keyser, J. Bresnan, and L. Gleitman (Cognitive Theory and Mental Representation); and Lila Gleitman, Susan Carey, Elizabeth Spelke, and Elissa Newport (Learning, Development and Conceptual Change).

Acquisition editors are Frank Satlow (Engineering and Computer Science); Laurence Cohen (Physical Science, Applied Mathematics, and Philosophy); Roger Conover (Architecture and Design Arts); Robert Bolick (Business, Economics, and Linguistics); and Harry Stanton (Cognitive Sciences, Bradford Books).

BOOK PRODUCTION

Under the direction of Helen Osborne, managing editor, and Dick Woelflein, production manager, the editorial and production departments produced many fine books. In addition to the publication of 127 new books, 97 books were reprinted.

Computergraphics, under the management of Mildene Bradley, composed 45 books on the computerized typesetting system, totalling approximately 10,862 book pages, at a break-even cost for the Department's first complete fiscal year.

The design department, under the management of Sylvia Steiner, continued to produce fine book and jacket designs, winning multiple awards from the Boston Art Directors Club, the American Association of University Presses, the New England Book Show, and the American Institute of Graphic Arts Show.

BOOK SALES

Under the direction of Thomas McCorkle, the marketing department sold 420,441 books this year: 164,041 hardcovers and 256,400 paperbacks.

CUSTOMER TYPE	Fiscal Year 1983	Fiscal Year 1982	Fiscal Year 1981
College Bookstore	$ 885,456	755,834	734,601
Retail Bookstore	1,108,621	1,123,638	840,103
Wholesale/Jobber	1,042,245	848,628	783,168
College/University Library	123,597	107,269	109,102
Direct Mail	388,469	341,545	257,450
Other	346,915	341,929	333,696
TOTALS	3,895,303	3,518,843	3,058,120

Sales to wholesalers and jobbers increased by 23 percent this year, in part because of titles that did particularly well through jobbers. Paperback dollar sales increased because of price increases, but paperback unit sales decreased by seven percent. Hardcover dollar sales increased 9.7 percent and hardcover unit sales increased 5.8 percent, mainly due to wholesaler increases.

International sales represented approximately 25 percent of total sales. Solid sales increases in Canada and Asia (outside Japan) and modest increases in the United Kingdom compensated for large sales declines in Japan and Latin America. Mexico, which usually accounts for half of total Latin American sales, was eliminated as a book market this year when the Mexican government imposed severe import restrictions.

International Sales, Fiscal Year 1981 - Fiscal Year 1983

	Fiscal Year 1983	Fiscal Year 1982
Australia	$ 36,000	$ 42,000
Canada	206,000	187,000
Japan	194,000	238,000
Rest of Asia and Other	119,000	94,000
Latin America	27,000	48,000
UK,Europe,Africa and Middle East	580,000	543,000
TOTAL	1,162,000	1,152,000

Subsidiary rights income declined 30 percent this year, as income ceased from unusually large paperback rights sales made in fiscal years 1979 and 1980.

Subsidiary Rights Income, Fiscal Year 1981 - Fiscal Year 1983

	Fiscal Year 1983	Fiscal Year 1982
Translation Rights	$ 28,335	$ 34,240
Book Club Rights	12,647	18,332
Reprint Rights	15,844	28,330
TOTAL	56,826	80,902

Direct Mail and Promotion

Under the direction of Brooke Stevens, promotion manager, direct mail income increased $47,000, from $341,000 to $388,000. Direct sales to libraries and individuals rose 55% from 1981. Review attention, in both professional/technical and popular media, continued to grow, with trade science books garnering special attention, in particular *Abusing Science* by Philip Kitcher and Helmut Tributch's book *How Life Learned to Live*. Efforts were made to expand the market for specialized books, which resulted in treatments ranging from an illustrated, boxed review in the *New York Times Book Review* for Johann F. Geist's *Arcades*, to a glowing recommendation by ABC's naturalist Roger Caras for *The Aquarium Encyclopedia* edited by Gunther Sterba.

The text promotion program continued to reach a wide audience. Mailings were sent to professors in Architecture, Linguistics, Economics, and Sociology. Among the texts that did particularly well this year were the paperback edition of *The Myth of Masculinity* by Joseph Pleck and the hardback edition of *Robot Manipulators* by Richard Paul.

THE MIT PRESS BOOKSTORE

The Bookstore continued growing with gross sales of $121,400, a $21,400 increase over last year.

Best selling hardcovers were *Robot Motion: Planning and Control* edited by Michael Brady et al., *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* by Harold Abelson and Andrea diSessa, and *The Language Lottery: Toward a Biology of Grammars* by David Lightfoot. Best selling paperbacks included *Bicycling Science*, second edition, by Frank R. Whitt and David G. Wilson, *John von Neumann and Norbert Wiener* by Steve J. Heims, *Some Concepts and Consequences of the Theory of Government and Binding* by Noam Chomsky, and *Modularity of Mind* by Jerry A. Fodor.

The bi-annual Sala Sale sold over 40,000 damaged books in three days, with gross sales of over $60,000.

JOURNALS DEPARTMENT

MIT Press Journals has steadily expanded over the last five years, and now publishes eighteen scholarly and professional journals in a wide range of disciplines. In February of 1983, the department moved to new office space on the second floor of the Suffolk building to accomodate the increased list of titles, additional staff members, and newly acquired computer hardware. Within the year the division acquired a fourth CRT, an Apple II Plus, and a Decmate Word Processor.

The Journals Division closed fiscal year 1983 with a net surplus of $202,583, an increase of 40 percent over last year's surplus. The gain was on earned income of $2,134,837. $90,163 was added to the reserve account (unearned subscription income) bringing the total reserve to $871,600, an increase of 11.5 percent over fiscal year 1982.

In April 1983, the Division took over publication of *Design Quarterly*, a publication of the Walker Art Center focusing on contemporary design. In June, *The Washington Quarterly* joined the program, and in September *Places*, a new journal of environmental design, will be launched, co-edited by William Porter (MIT) and Donlyn Lyndon (UC/Berkeley).

Other journals in the program are *Cell*, edited by Benjamin Lewin; *Computer Music Journal*, edited by Curtis Roads; *The Drama Review*, edited by Michael Kirby; *Journal of Interdisciplinary History*, edited by Robert Rotberg and Theodore Rabb; *International Security*, edited by Albert Carnesale and Michael Nacht; *Linguistic Inquiry*, edited by Jay Keyser; *Milbank Memorial Fund Quarterly*, edited by David Willis; *October*, edited by Annette Michaelson and Rosalind Krauss; *Harvard Architecture Review*, sponsored by the Graduate School of Design at Harvard University; *Perspecta*, sponsored by the School of Art and Architecture at Yale University; *Via*, sponsored by the Department of Architecture, University of Pennsylvania; *International Journal of Robotics Research*, edited by Richard Paul and Michael Brady; and *International Organization*, edited by Peter Katzenstein.

Via 5 was the winner in the Association of American Publisher's category for Excellence in Design and Production, Journals Looseleaf and Other Media. *Perspecta 18* was cited in *MS* magazine for being edited and designed by women for the first time in its almost 30 year history, and *Perspecta 19* received an honorable mention in the Association of American Publisher's Best Single Issue of a Journal category. *Cell* continued to win critical aclaim throughout the world and circulation now totals 6,000 subscribers.

The Systems Development Foundation awarded the Journals Department a grant of $50,000 to aid promotional efforts for *International Journal of Robotics Research* and *Computer Music Journal*. The Pinewood Foundation provided support to *October*, and the Milbank Memorial Fund provided a subsidy for the editorial activities of the *Milbank Memorial Fund Quarterly*. The National Endowment for the Arts provided $23,000 for translation and promotional costs of *Space and Society* and contributed to the new journal, *Places*.

In April of 1983, the Journals Circulation Department began an experimental on-line computer program called Pub LINX with F. W. Faxon Company, one of the largest subscription agencies in the country. The purpose of this experiment is to develop a pilot program that makes FAXON publisher files available to the publisher and explores a variety of needs that an on-line connection between publisher, subscriber, and subscription agency might meet.

FRANK URBANOWSKI

News Office

MIT found itself mentioned on numerous occasions in the national news during 1982-83.

Alumni achievements were, in part, responsible--i.e., one alumnus and former professor, George P. Shultz, was appointed Secretary of State, two alumni flew in space shuttle missions (William B. Lenoir, also a former professor, in Columbia and Frederick H. Hauck in Challenger), and still another alumnus (and research staff member), Byron K. Lichtenberg, was picked for a future flight. Two alumni--Marcia Kaptur of Toledo, OH., and Bruce A. Morrison of New Haven, Ct.--were elected to Congress (bringing to six the number of MIT alumni serving there).

But equally noted were achievements, adventures, and exploits of faculty, students, and staff. The Group Velocity student group made newspapers and television in a bid for a pedal-powered speed record with a bicycle built for five. Professor Robert A. Weinberg received widespread attention in connection with the identification of tumor causing genes. Dean John Deutch was in the news as a member of the White House Scowcroft committee studying MX missile siting. Two professors--Martin Diskin and John B. Stanbury--were in the news as members of separate and unconnected groups of American observers in troubled El Salvador. Pictures of Professor Harold Edgerton celebrating his 80th birthday with a cake baked for him in the form of a bullet passing through an apple also appeared nationwide.

University programs also made news. National Research Council graduate school ratings placed several MIT departments at the very top nationwide. Prospects for the new Arts and Media Technology Building now under construction began stimulating press excitement. The university's tuition increase drew press attention as did the university's annual payment to Cambridge in lieu of taxes (presented by MIT cheerleaders to the Cambridge mayor for a picture that was used widely). Other stories included growing difficulties for graduates seeking employment, the university's three-year plan to reduce spending, and presentation of a nuclear weapons freeze petition to Congress from some 3,000 faculty students, staff, and employees. Announcement and election of eight journalists to be MIT's first Vannevar Bush Fellows made news as did the MIT Symphony Orchestra concert in Carnegie Hall, the commencement address of former German Chancellor Helmut Schmidt and the life-long learning study executed in the Department of Electrical Engineering and Computer Science on the occasion of the 100th anniversary of the founding of that course of study at MIT.

The two stories that made perhaps the biggest MIT news for the year, however, were quite unrelated. Almost everyone in America last fall was amused when newspapers and television reported that MIT students (actually, members of Delta Kappa Epsilon fraternity) had rigged a large weather balloon that mushroomed from beneath the playing field at the annual Harvard-Yale football game in Harvard Stadium and many news media declared MIT to be the ultimate winner of The Game. At year's end, MIT drew additional widespread attention with the announcement of Project Athena in which the nation's two largest computer makers--IBM and Digital Equipment Corporation--will join with the Institute in a five-year project to explore new ways that personal computers, networks, graphics units, and central processors can be harnessed to enrich, broaden, and deepen teaching in virtually all fields of study.

Despite somewhat diminished resources, MIT News Office activities remained brisk. The office issued 174 press releases and photo stories during the year, of which 29 related to research results and 38 related to art, music, drama, etc. There were 38 issues of Tech Talk totalling 328 tabloid pages. Tech Talk carried three separate supplements at different times during the year: the President's Report; Arts in the News; and Interim Report of the Committee on the Changing Nature of Information. One issue was given over to the Independent Activities Period time table. At year's end, there were 537 mail subscribers to Tech Talk--307 paid individually, 230 paid by the university, and 74 complimentary.

A major activity was conversion of Tech Talk to new electronic word processing and typesetting systems, a difficult undertaking superintended with professionalism and dedication by the editor of Tech Talk, Joanne Miller, assisted by support staff members Donna A. Harris, Lisa E. Hirsh and Eileen J. Kennery.

An addition to the staff was China Altman, widely known Boston-based journalist, who accepted appointment as Assistant Director with special responsibility for publicizing MIT activities in art, music, drama, dance, etc. By the close of the year, she had made impressive headway in both organization and achievement.

Significant contributions also were made to the News Office programs by Assistant Directors Charles H. Ball, Robert C. DiIorio, and Calvin D. Campbell (photojournalist) as well as Ms. Harris, the office administrative assistant, and Ms. Hirsh, who has charge of tracking of press releases in progress and their ultimate production and distribution.

ROBERT M. BYERS

Office of Admissions

More than at any time in recent memory, for both the graduate and undergraduate applicants, the focus on those disciplines that appear to assure a favorable position in the job market was intense. This leaves some of the other traditionally attractive disciplines undersubscribed. The increasingly widespread availability of the computer in the secondary schools also tends to accelerate the trend toward the Department of Electrical Engineering and Computer Science, stretching that department's capacity to respond. In addition, students are tending to allow the drive to acquire computer skills to stifle the personal development which usually occurs during the important period of adolescence. For some even the basic skills in mathematics and English are being neglected.

This has been the year in which, nationally, elementary and secondary education has been studied intensively, with a number of groups calling for an increased commitment to a return to basic disciplines and to rigor in the schools. The effort is overdue and will generate discussion and possibly conflict in the months ahead. Even the very special young men and women who come to MIT can be better prepared for the challenges of college level work. Special they are, for they come from every social and economic group in the world that offers the opportunity to prepare for MIT subjects. The MIT Admissions Office, for its part, contributed to the awareness of the value of an MIT education through publications, correspondence, meetings, and the application process.

Despite the continued decline in the traditional college age population, a 1983 applicant group larger than last year's materialized. During the fall, the Admissions Office staff traveled to 101 cities carrying the MIT message, holding meetings with students, parents, school officials, and alumni/alumnae. The challenge continues to be to offset the narrow image associated with MIT's demanding intellectual environment and to articulate the breadth and positive spirit actually found here.

Despite our efforts to increase the number of minority students, we admitted and expect to register about the same number as last year. We are, as an office, committed to the effort and the challenge of attracting members of the underrepresented minority groups.

Educational Counselors

Approximately 1575 alumni/alumnae (including 160 women and 55 minorities) served as Educational Counselors (ECs) during the 1982-83 academic year. Collectively, these ECs conducted over 6,000 interviews for admission to MIT and spoke with countless other students and parents at local high schools, providing information about MIT and MIT's admissions process.

A student, Susanne Von Rosenberg, '83, was hired to coordinate a project to encourage current MIT students to increase interactions in their home towns with high school students, school personnel, and Educational Counselors. The project met with modest success during its first year. Approximately 40 students were identified as student coordinators for their hometown areas, and numerous other students participated in visits to high schools, phone calls to applicants, and participation in meetings with Educational Counselors and applicants during holiday periods.

ADMISSIONS TRENDS 1976-82

	1976	1977	1978	1979	1980	1981	1982	1983
Entrants from Secondary Schools								
Preliminary applications	8,104	7,853	9,320	10,274	11,223	12,526	12,769	12,653
Final applications	5,194	4,838	4,870	5,368	5,677	5,922	5,688	5,959
Admissions offered	2,277	1,939	1,865	1,813	1,809	1,909	1,911	1,818
Actual registrations	1,044	1,073	1,059	1,059	1,081	1,031	1,109	1,082
Registrations as percent of admissions	47%	55.3%	56.7%	58.4%	59.7%	54%	58%	59.5%
Number of secondary schools represented	866	859	877	893	894	835	904	884
Percent of students from nine northeastern states	48%	52%	50.6%	49%	47.8%	51.9%	49.9%	51%
College Transfers								
Total applications	941	1,079	1,074	1,143	1,131	818	1,006	819
Applications completed	536	591	535	486	471	399	409	472
Admissions offered	203	175	172	152	167	93	128	118
Actual registrations	162	141	123	124	119	76	95	82
Registrations as percent of admissions	80%	81%	72%	82%	71%	82%	75%	69%
Graduate Students								
Total applications	7,511	7,740	7,454	7,849	7,832	9,075	9,239	8,836
Admissions offered	2,676	2,644	2,724	2,636	2,380	2,926	2,935	3,037
Actual registrations	1,441	1,369	1,461	1,362	1,212	1,465	1,592	1,541
Registrations as percent of admissions	54%	52%	54%	52%	51%	50%	54%	51%

PETER H. RICHARDSON

Office of Career Services and Preprofessional Advising

The Office began the year as the Office of Career Planning and Placement and ended it as the Office of Career Services and Preprofessional Advising. The responsibilities of the Office were broadened during the year when Linda Stantial left to become Director of Placement at the Sloan School and Jeannette Gerzon came to us from the Office of the Dean for Student Affairs bringing with her the responsibility for coordinating the advisory program for students applying to medical school and law school. With the start of the new fiscal year the Office also takes over from the Dean's Office the responsibility for advising students interested in study abroad. The addition of these new responsibilities without an increase in the size of the Office reflects the Institute's determination to pare the budget for support services. We believe we can continue the same services students and alumni have enjoyed in the past without loss of effectiveness. Indeed, we hope we can continue to make improvements, and serve them better.

The recession and its impact on the job market tested our responsiveness to students' needs. For students in many disciplines it was a difficult year to look for a job. Employers sent out fewer recruiters and were slow in making offers. Chemical engineers were particularly hard hit. The oil and chemical industries cut back their campus recruiting sharply and the interest of other employers in chemical engineers could not take up the slack. Firms telling us of their offers to students (unfortunately, only a fraction of employers) reported only one-fourth as many offers to chemical engineers as the year before. Statistics published by the College Placement Council indicate that there was a similar drop in the number of offers nationwide. Early returns from the students themselves suggest that they were not unsuccessful in finding jobs - even good ones - but it is clear that they had few offers among which to choose. Salaries in chemical engineering remained unchanged from the year before, which means that they declined in real terms.

Students in other fields also found job hunting a challenge. For example, mechanical engineers, like chemical engineers, were hurt by the drop in the price of oil and the disarray in the energy industry. But there is a need for mechanical engineers in nearly every industry and when students began to receive offers they were higher than the year before, even after inflation.

The two fields in which demand was strongest were electrical engineering and computer science. The demand came from every sort of employer, from electronics firms to investment banks, from government laboratories to entrepreneurs hiring their first employees. The fact that many well-known computer firms had hiring freezes and some had layoffs did not darken the overall picture. If some firms were not hiring, there were a great many others who were. Firms reported as many offers as the year before. Offers at the bachelor's and master's level moved up faster than the inflation rate. Offers to doctor's degree recipients increased, but at less than the inflation rate.

The number of employers coming recruiting fell to 405 from 450 the year before. This compares with 406 in 1980-81. However, many firms sent fewer recruiters and they were much more interested in certain fields than in others. It was not a good year to look for summer jobs. A total of 1,401 students, most of them looking for permanent employment, had 9,675 interviews. The comparable figures in 1981-82 were 1,556 and 10,004. The average number of interviews per student was 6.9, compared with 6.4 the year before, 5.8 in 1980-81, and 4.9 in 1979-80. The increase in the number of interviews per student reflects a growing concern among students about finding a good job after graduation. This year, on many days when the interview notices were posted, they stood in long lines outside the Office waiting to sign up. Their numbers were increased by a number of graduates from the year before who had not found a job by graduation or who had found a job and been laid off. For the first time in our experience we had to balance the needs of students and alumni. We are concerned that we may have to find ways of rationing interview appointments in 1983-84 if employer demand continues to be slow.

A total of 793 students submitted resumes for the Science and Engineering Resume book which we distribute to employers - enough to swell the publication to three volumes. Foreign students without immigrant visas who faced a more dismal economy at home than they saw here, pressed us hard to help them find work in the United States. The Simpson-Mazzoli Bill which is currently before Congress promises to limit severely our already limited ability to help foreign students wishing to stay and work in this country, but we intend to see what more we can do. We were invited to speak to numerous student groups about the job outlook and job hunting techniques, as well as organizing counselling meetings ourselves. These meetings were generally very well attended.

PREPROFESSIONAL ADVISING

There was a significant decline in the number of M.I.T. applicants to medical school. A total of 101 candidates filed applications, compared with 130 in 1981-82. They included 69 seniors, 12 graduate students, and 19 alumni. Incomplete returns indicate that 77 were accepted and another 5 were on waiting lists. A total of 98 seniors, graduate students, and alumni were accepted in 1981-82. The acceptance rate among M.I.T. candidates shows no sign of dropping. Indeed, the acceptance rate among graduate students and alumni - 71 percent - was close to a record. Seven were accepted who had been turned down previously. It is clear from the stories of graduate students who have applied before from other institutions that M.I.T. can be proud of the help it gives to candidates. The application process remains a competitive and chancy business. Our candidates applied to an average of 13.2 schools last year. Several were accepted at only one school, often not the school they would have most expected. A number of good candidates are unsuccessful each year because they cannot be persuaded to apply at enough schools.

We know of 39 M.I.T. candidates who applied to law school, approximately the same number as the year before. Eleven were students, the rest alumni. We do not yet know how many were admitted.

ALUMNI

Between five hundred and six hundred alumni approached us during the year inquiring about the job market. At the end of the year 266 were regular recipients of our fortnightly listing of job listings, the Gazette, for which we now charge $10 for a six months' subscription ($18 for a year). We are eager to alert employers to the existence of the Gazette, as well as alumni, and we are advertising it in Technology Review. The ads are attracting job listings and subscribers.

STAFF CHANGES AND REORGANIZATION

We miss Linda Stantial and wish her well in her new job at Sloan. She was responsible for our services to alumni for nine years, after previously learning the ropes from Evelyn Yates. She had the needs of alumni very much at heart and won a wide circle of admirers by her thoughtful counselling.

The new responsibilities we have acquired since her departure have led us to reorganize our services to students and alumni. Now all of us who are engaged in counselling talk with alumni in their areas of particular concern. Elizabeth Reed covers architecture, urban studies, the social sciences, and civil engineering. Jeannette Gerzon covers medicine, law, the life sciences, chemistry, and chemical engineering. The director covers the rest of the field. Patricia O'Connor, editor of the Gazette, is our catcher, making sure someone always has the ball. We are delighted to have been able to add Jeannette Gerzon to the team. We welcome her intelligence, understanding, and enthusiasm. Thanks are owed to all of the staff, not least to Phyllis Jackson and everyone else involved in the recruiting program, for a job well done in a difficult year.

ROBERT K. WEATHERALL

Personnel Office

The reports which follow highlight the past year in the four sections that now comprise the MIT Personnel Office.

The office sections and major responsibilities, are:

Compensation and Employment assumes responsibility for salary, wage, and benefits administration for the total Institute and recruitment, referral, and employment approval for all nonacademic employees.

Faculty and Staff Information Service assumes responsibility, through two sections, for the receiving, processing, and storage of employment information of faculty and staff. The office also is responsible for privacy of access to these records and for monitoring the employment and salary information for all members of the community. Service is provided through two units: the Faculty and Academic Staff Records Office and the Personnel Information Services Office.

Labor Relations assumes responsibility for interpreting, negotiating, and administering all union/management agreements of the Institute. Presently the Institute has eight agreements with five separate unions.

Personnel Services and Development assumes responsibility for development and interpretation of personnel policies and procedures, service to departments and staff, screening and referral of candidates for positions, and development and direction of training programs.

The present structure has been very effective in meeting the needs of personnel services to the community in a period of restrictive budgets. While there were many accomplishments over the past year, I have listed below a few of those that I believe are representative of the dedicated and enthusiastic efforts of the entire staff.

- reappointment of members of the exempt payroll to appropriate staff categories of the Institute. This proposal was approved by the Academic Council after a major study showed that the exempt payroll could be eliminated with benefit both to the employees concerned and the Institute.
- initiatives in the formation of an Ad Hoc Committee on Retirement Related Benefits of MIT Employees. This committee met extensively over the past year recommending pension improvements for both retired and active employees which were approved by the Institute.
- extensive improvements in the computer and word processing support of the entire office.
- continued efforts in conducting and organizing programs of development for employees, using MIT faculty and staff as presenters.

A number of changes in staffing occurred during the year. Richard Cerrato left the Personnel Office for a new position as Assistant Director of Housing. He was replaced as Senior Personnel Officer by Susan Gaskell, who joined the Campus Personnel Office from the Lincoln Laboratory Personnel Office. Kenneth Chin joined MIT from a position at Harvard University. Vera Ballard left the Personnel Office to assume a new administrative position with the Whitaker College of Health Sciences, Technology and Management.

JAMES J. CULLITON

COMPENSATION AND EMPLOYMENT

Wage and Salary Administration

The Wage and Salary Office carried out its primary goal of equitable administration of the compensation structure for each of the Institute's faculty, staff, and employee groups, now numbering over 8,000 individuals, including responsibility for conducting all annual performance reviews. In preparation for the annual reviews for each employment group, the Wage and Salary Office participated in approximately 30 outside salary surveys and conducted three major surveys of its own (faculty, administrative staff, and research staff). Through these surveys, the office assesses the compensation relationship between the Institute's salary structures for its faculty and staff and its competitors on a national, regional, and/or local level. As a result of these surveys, appropriate adjustments were made to the Institute's existing salary scales, and performance reviews resulting in merit increases were put into effect.

MIT's 1983 faculty salary survey of 24 comparable universities nation-wide showed that the Institute has maintained a favorable position among most universities with which we compete. Our efforts in past years to focus in particular on the salaries of junior faculty have resulted in an improvement in position at both the assistant professor and associate professor levels. The survey data returned to the participants was expanded this year to provide data by individual school, as well as by professorial and institutional rankings.

A major accomplishment of the year was the submission of an extensive proposal, subsequently approved by the Academic Council, to phase out the exempt payroll by reappointing almost all of its members to appropriate staff classifications on campus (administrative, sponsored research, or academic), and to a new professional category of Specialist at Lincoln Laboratory. The reappointment option was offered to approximately 410 individuals. By June 30, 365 had elected the staff option. This major effort required detailed communication to each Exempt staff member, both in written form, and through a series of informational meetings on campus, at Lincoln Laboratory, and at Haystack. The cooperation of the Benefits, Treasurer's, and Payroll Offices was invaluable in carrying out this reappointment process.

The Staff Salary Administration Program continues to provide a stable and useful guide in the assessment of positions on the administrative staff. Approximately 400 positions have been reviewed by the Wage and Salary Office since the Program's modification five years ago. Of these, 58 positions were reviewed this year, including 17 requests to evaluate new positions, 24 promotional recommendations from suppport and exempt staffs, and 17 requests to reassess existing positions. These reviews resulted in the assignment of equitable salary ranges for these positions while at the same time adding important information to our database. An ongoing task in the Wage and Salary Office will be to evaluate the positions of those staff members newly reappointed from Exempt, and to assign appropriate salary ranges within the Staff Salary Administration Program.

The attention paid to the salary scales for the support staff has resulted in the Institute's continued favorable position with respect to major Boston-area employers. The position standards developed several years ago by the Working Group continue to be useful, fair, and workable guidelines for reaching equitable decisions regarding individual support staff positions, and in particular for assessing requests for promotion within the support staff. The position standards contribute substantially to the use of all ranges within the support staff structure.

Benefits Administration

The Benefits Office completed space and electronic renovations to complement its recent reorganization into three sections. These renovations included building a reception area and installing terminals for access to the Personnel Office database. The addition of a word processing system has enabled the office to revise and automate production of many of its basic procedures and to begin to document these procedures in a systematic manner.

Work continued on the development of benefits database which is expected to come online in FY84. This database will enable further streamlining of information processing and record keeping, as well as provide more complete data to use in benefits counselling and in analysis of the 22 benefit plans now administered by the Benefits Office.

In the fall and winter, office members provided extensive staff support for an Ad Hoc Committee on the Retirement Related Benefits of MIT Employees. The Committee recommended adjustments in pension benefits, both for retirees and for active employees, to help counteract the effects of heavy inflation in recent years. These improvements are expected to be made early in FY84.

In the health insurance area the Blue Cross inpatient psychiatric coverage was improved. In October, 1982, a fourth health insurance option was added: the Multigroup Health Plan, a health maintenance organization with several centers near Lincoln Laboratory. The Benefits Office also began to explore ways of containing MIT's expenditures of health insurance, which have increased far above the inflation rate in recent years.

During the past year the Benefits Office conducted 93 workshop sessions on benefits for current employees, including pre-retirement seminars, tax-deferred annuity workshops, and special sessions on layoffs and the exempt-to-staff transfer. We also held 80 orientation sessions for new faculty, staff, and employees, and introduced a revised format for the Benefits Summary 1982. In addition, the Benefits Editorial Committee, formed in the fall of 1981, met more than 40 times during the year to continue its revision of all ERISA Summary Plan Descriptions. The Editorial Committee is comprised of members of the Benefits Office, the Wage and Salary Office, the Treasurer's Office, and the Medical Department. At the present time it has completed work on ten of eighteen documents.

Employment Activity

The non-academic population on campus as of June 1, 1983, was 4,800. While budget constraints caused cutbacks in the administrative, service, and support staff payrolls, the decline was for the most part offset by an increase in the sponsored research staff payroll, resulting in a decrease in the overall population of only .3%.

A total of 860 positions were posted during the year, 13% fewer than during the previous year. Personnel Officers interviewed 1,250 applicants, primarily for available support staff positions. Approximately 70% of these applicants were referred to one or more supervisor(s), generating 2,450 departmental interviews. Additionally, 6,050 resumes were received, reviewed, and acknowledged with a personal letter. Of these approximately 80% were referred to departments to be considered for available positions. From this applicant pool of 7,300, 640 were hired. In addition, 175 employees successfully transferred into new positions within the Institute during the past year.

KERRY B. WILSON

FACULTY AND STAFF INFORMATION SERVICES

During the past year, office automation and its effects have been the primary focus of activities for the Faculty and Staff Information Services (FASIS). The Systems Section has continued with the successful implementation of the Personnel Employee Records System (PERS), making a number of specific gains.

With the acquisition of additional IBM terminals, most members of the Personnel Office now have direct access to the employee database. Acceptance of the new system has been excellent; and suggestions from members of the Personnel Office have improved the accuracy of employment records.

Acquisition of a line printer has enabled the Systems Section to improve it ability to generate printed reports on a timely basis and has increase the confidentiality of sensitive documents that were formerly printed at remote locations. In addition, this device has enhanced the capability to respond to requests for reports from other Institute organizations.

Implementation of the benefits and applicant flow portions of PERS is well under way, with completion set for the Fall. At the same time, a number of major report generators have been completed and tested against the on-line computer files. Continued attention to the need to reduce paperwork and to improve current procedures has led to the creation of a number of new reports that further reduce the labor-intensive aspect of FASIS operations while simultaneously improving the scope and timeliness of needed reports.

In response to growing pressures for the use of departmental word processing facilities, the decision was made to decentralize access to the facilities by adding several independent word processing systems. By acquiring devices that serve as both word processors and personal computers, FASIS hopes to continue the process of automation of routine aspects of written communications while at the same time effecting a general increase in computer literacy within the Personnel Office. Again, the acceptance of these devices has been excellent; and demand is growing for training in personal computing and word processing.

The increased automation of work within FASIS continues to affect staffing needs and will almost certainly produce reorganization and further realignment of responsiblities with the coming year.

ISAAC M. COLBERT

LABOR RELATIONS

In August 1982 the Institute and the Campus Police Association concluded negotiations for a new two year Agreement terminating on June 30, 1984. Wage increases of 10% and 6.5% in each year of the Agreement were agreed to by the parties along with minor changes being made in contract language.

Negotiations opened in May of 1983 with six of the Institute's seven bargaining units that are represented by three different international unions and one independent union. James J. Culliton, director of Personnel, is serving as chief negotiator and spokesman for the sessions with the Service Employees International Union and the Hotel, Restaurant, Institutional Employees and Bartenders' Union bargaining units. James J. Fandel, manager of labor relations, is spokesman for the Research, Development and Technical Emgployees' Union and the Independent Union of Plant Protection Employees bargaining units. The Institute and the Unions have been meeting regularly for seven weeks. We look forward to an equitable conclusion to the negotiations for new labor Agreements.

The grievance and arbitration process has stabilized at a very high volume. There are currently thirty-four arbitrations awaiting hearings. The issues include supervisors performing bargaining unit work, discpline, discharge, promotions, layoff, safety, and other contract interpretation matters. However, the parties' abilities to reach mutually satisfactory conclusions to a number of outstanding arbitrations prior to the final hearing dates has improved markedly over the fiscal year. At the present time there are twelve (12) pending arbitrations in the process of being resolved by the parties.

The Office has continued its program of planning and presenting labor related subjects for departments and laboratory groups during the year. The topics discussed include the duties and responsibilities of managers for labor relations policy, application of discipline, absenteeism, contract administration and the performance of bargaining unit work by non-bargaining unit personnel. Plans have been made to continue this work in the next fiscal year.

JAMES J. FANDEL

PERSONNEL SERVICES AND DEVELOPMENT

As in the past, Personnel Officers' responsibilities include personnel policy interpretation, salary and classification review, applicant and transfer referral, personal and career counseling, affirmative action and Institute representation in union matters.

Changes were made in Personnel Officer assignments to accommodate a reduction in staffing, from nine to eight Personnel Officers.

Over 3,000 employees took advantage of Personnel sponsored programs. Of the 18 different types of programs offered, some of which were offered more than once, all but six presenters were MIT personnel with expertise in the subject. In addition, approximately 800 people attended at least one of the talks entitled Perspectives, a series of seven separate presentations by faculty members, which were sponsored by Personnel, in conjunction with the Provost's Office and the Sloan School of Management.

The Office has endeavored to establish closer ties with senior officers in order to discuss their concerns regarding personnel matters, especially in relation to budgetary limitation and the necessary reductions in staffing.

JOAN F. RICE

Quarter Century Club

The MIT Quarter Century Club was founded in 1950 and became an Institute administrative department in 1978, reporting to the Vice President in the Office of the President.

The membership of the Club now totals over 1600, with each member having served the Institute for more than 25 years. The annual meeting, at which new members are inducted into the Club, takes place in the spring. This marks the final year in which The Charles Stark Draper Laboratory employees whose combined MIT and Draper Laboratory service equals 25 years will be made members of the Club. Draper Laboratory is now in the process of forming its own Quarter Century Club. Other annual functions include a picnic in the summer and a holiday gathering in December. The Club also provides administrative and logistical support to the Institute's annual charitable campaign and to its retirement dinner in June, as well as special functions when requested by the Administration.

For a trial period commencing in January, the Club has been providing administrative support for the MIT Activities Committee (MITAC) which serves the Institute community in recreational and cultural activities. This will become a permanent function of the Club in the coming year.

An extensive travel program is organized for the alumni, retirees, and the Institute community offering approximately 100 departures to various destinations annually. Some of these include lectures or other educational aspects.

An extensive revamping of the Constitution and Bylaws was completed in April. There are four officers and eight directors on the board. The staff of the Club consists of Ann P. Brazier, manager, and two assistants, M. Frances Daly and Nanci Drago.

PHILIP A. STODDARD

Council for the Arts

When the Council was established in 1973, the objectives were to create a self-supporting organization which would actively promote student participation in the arts, enhance the visual environment, and plan for better cultural facilities. Over the past year, we have been most successful in fulfilling each of these objectives. The Arts and Media Technology center, initiated and supported in large part by the Council, is nearing completion. The Permanent Collection Committee has vigorously assisted the Institute with its collection of public works of art and art loaned to students. This advisory body has been so effective that it will serve as a prototype for Council liaison committees with faculty in architecture and the performing arts. Our grants program, through increased publicity, technical assistance, and an expanded budget, substantially raised the level of student participation in arts activities. And this year, for the first time in Council history, 100 percent of our budget was contributed by Council members and friends.

To continue to meet these objectives as the needs and opportunities of members of the MIT community change, the Council has to adapt its programs, services, and membership. Accordingly, we substantially changed the Council membership so that the full range of arts disciplines at the Institute are represented. Our membership now provides the leadership and imagination to encourage new directions in all aspects of MIT art activities. We also undertook a major evaluation of the grants program and a study of Council-generated support of the arts. Finally, we are studying ways of strengthening the performing arts, of increasing the exposure of MIT arts programs to a broader audience, and of developing criteria by which improvements in the arts can be evaluated.

ARTS PROGRAMMING

The Grants Committee, under the chairmanship of Lewis Cabot, reviewed 67 proposals and awarded 45 grants. Over $50,000 was allocated in grants to individuals and organizations associated with the Institute. These grants were matched by $28,000 of cash support and an estimated $44,000 of in-kind contributions. A record number of awards went to students and student organizations -- a trend that we hope will continue in the future.

One of the most successful projects was an outdoor dance event choreographed and produced by staff members Renee Caso, Laura Knott, and Lynn Modell. Another grant to the Chorallaries, an MIT singing group, assisted with their tour to high schools throughout California. Support for John Stautner, Research Associate at the Experimental Music Studio, has enabled him to collaborate with Korean pianist Kun Woo Paik, to create a computer-modified ambience for a performance of Scriabin piano works.

A grant to the Class of 1983 established an exhibition fund to renovate the East Lounge of the Student Center for use as a gallery and arts information area. The students are naming it the Jerome B. Wiesner Student Art Gallery. Support to the MIT Symphony Orchestra for their Carnegie Hall performance this April was greatly enhanced by the publicity provided by Council members. Funds also enabled the Shakespeare Ensemble to sponsor workshops with local theatre professionals, and the Film/Video Section to undertake a variety of collaborative film projects. Five grants enabled visiting artists to present their work and/or to be in residence at MIT, including writers, dance companies, and musicians. Two commissions were awarded: one for a new work for solo viola, to be performed by Professor Marcus Thompson, and the other for a new piece by Visiting Professor James Dashow.

During its ten years of operation, the grants program has expended over $370,000 to support 269 projects, generating an additional $432,500 in matching gifts.

A growing program of technical assistance has been well-received by the MIT community. Our staff is called upon daily to assist with proposal writing and the preparation of budgets. Students, staff, and faculty regularly refer to information and publications regarding funding opportunities in our research library. To better acquaint the community with our staff services and programs, we scheduled our first Open House at the Council offices in September.

For the third consecutive year, Council efforts and support ensured continued Institute participation in the Boston Museum of Fine Arts' group membership program. All MIT students were thereby entitled to free admission and other Museum privileges. The number of MIT student visits recorded by the Museum this year increased from approximately 9,500 to over 13,500. A new program of membership cards for faculty, staff, and associates was begun. Cards can be checked out of the Humanities Library for three days at a time. To introduce MIT community members to the Museum, Stacia Zabusky, administrative assistant, helped organize an evening of events and tours at the Museum in April. "The Event" was coordinated with four other colleges and universities in the Boston area, and attracted over 300 members of the MIT community.

As a way of increasing the exposure of the arts at MIT, the Council continued its popular series of "salons." These occasions feature MIT artists who present or discuss new works. Twenty to forty guests assemble for an informal program followed by dinner. Because of the enthusiasm generated by our last salon, held in Dedham, Massachusetts, and hosted by Council member Bradford Endicott, we began this year with a salon in Boston at the home of Council member Frances Fahnestock. Guests shared the evening with MIT composers John Harbison and Barry Vercoe. Following dinner there was a concert of their work at MIT's Kresge Theatre. In New York City, our hosts for an evening with playwright Albert R. Gurney, Jr., were Council member John Kunstadter and his wife, Geraldine. Discussion focused on Professor Gurney's Off-Broadway production, *The Dining Room*.

The Permanent Collection Committee (formerly the Acquisitions Committee), under the chairmanship of Ida Rubin, serves as an advisory body for the Institute's Committee on the Visual Arts. Two meetings were held to assess current needs for the Permanent Collection and to outline long-range plans for acquisitions. The most concrete result of these meetings was a gift of a Jennifer Bartlett painting by Council member Vera List.

A major endowment, the William L. Abramowitz Lecture/Concert Fund, was transferred to the Council after having been administered for 22 years by the Humanities Department. The $150,000 Fund was established by William L. Abramowitz '36 as a memorial to his father. The Council will now be responsible for continuing the tradition of bringing an established performing arts group or an artistic event of significance to MIT.

A growing number of endowed awards serve to recognize and celebrate art, artists, and art activities at MIT. The McDermott Award was presented this year to Council Secretary and Elizabethan scholar Roy Lamson, for major contributions to the arts at MIT. The Laya and Jerome B. Wiesner Student Art Awards, established by Council members in 1979, are given annually to individuals and organizations which have contributed significantly to the MIT community through the arts. Dr. Wiesner presented the awards this May to graduate student Barbara Hughey, concertmistress of the MIT Symphony Orchestra, for service to the performing arts, and to Peter Cerrato and Howard Kolodny, Class of 1983, for their poetry. The Gyorgy Kepes Fellowship Prize was established this year by Council member Angus MacDonald, with assistance from Margaret McDermott and Institute Professor Walter Rosenblith. In honor of artist and Institute Professor Gyorgy Kepes, the Fellowship will be awarded annually to an individual at the graduate or post-graduate level who has demonstrated a concern for human values as reflected in the relationship between art and the environment.

Jerome B. Wiesner, Chairman of the Council, and William L. Porter, Special Assistant to the President for the Arts, welcomed members of the Council and invited guests to the Eleventh Annual Meeting in Cambridge on November 12, 1982. The highlight of the morning session was an address by Robert Brustein, Artistic Director of the American Repertory Theatre in Cambridge and Professor of English at Harvard. He spoke to an audience of Council members, faculty, administrators, and students about the need for professional theatre within an educational context. As he put it, "without the performing arts no university can be complete." The morning session also included an announcement by Council member Angus MacDonald of an endowed Fellowship Prize in honor of artist Gyorgy Kepes.

John de Monchaux, Dean of the School of Architecture and Planning, and Council member I.M. Pei gave a program and construction report on the Arts and Media Technology center. By consolidating existing arts and media activities, and providing access to research and teaching in modern information technologies, the center will create new opportunities for the production, presentation, and dissemination of art. When the center opens in the fall of 1984, it will include extensive gallery, screening, and presentation areas. Academic programs included are experimental music, holography, computer graphics, computer animation, experimental print media, film, video, computers-in-education, and computational video, among others. The Council offices will also be re-located in the new center.

Luncheon concerts were followed by a selection of afternoon workshops in studios and laboratories throughout the Institute. At dinner ceremonies, Dr. Wiesner presented the McDermott Award to Professor Emeritus Roy Lamson. The Meeting ended with remarks by President Gray. He urged the Council to consider two goals for our next decade: "First, to see to completion the Arts and Media Technology facility, both in terms of achieving administrative and intellectual clarity in its program, and in completing the funding for the building, and second, to reassert your interest in the full spectrum of the arts at MIT."

MEMBERSHIP

The Membership Committee, under the chairmanship of Nelson Lees, met regularly to review proposals for Council membership. Barbara Allen, assistant director, arranged visits for prospective members with faculty and students at MIT. The Committee made every effort to identify new members who demonstrate scholarship, creativity, or distinguished service in the performing arts, the media arts, and the design arts. Through the success of these efforts, the membership is now more varied in its constituency and more congruent with the needs of the Institute. A greater number of members were enlisted this year than at any other time except the first years of Council formation. Twelve new members began three-year terms

in July 1982; seven were announced this year. They are: Annette Berger, NYC; Robert Greenes '42, NYC; Graham Gund, Cambridge; Ragnar Naess '25, NYC; Walter Netsch '43, Chicago; William Porter G'69, Concord, MA; and Frances Whitney, NYC.

Invitations for membership terms beginning July 1983 were accepted by Norma Asnes, NYC; Mary Ann Beinecke, Williamstown, MA; Dr. Jerome Grossman '61, Boston; Marilyn Hoffman, Washington, D.C.; and Ronald Kurtz '54, Englewood, NJ.

With Council membership restricted to 100, we cannot invite new members to serve the Institute without also asking some members to continue their service and association with the Council in a less formal manner. A growing group of Council 'alumni' is active in its support of MIT arts activities. Twelve members concluded their service as Council members in June 1983: Sarah Caldwell, Walter Campbell '26, George Henning '33, Frederick Lehmann '51, Katie Louchheim, Dorothy Rautbord, Jean Riboud, Samuel Sachs II, Ascher Shapiro '38, Sue Thurman, Harry Weese '38, and Dorothy Wilson. Three other members, Anna Bing Arnold, Betty Johnson, and Agnes Gund Saalfield, resigned after years of dedicated and active membership. We look forward to continued interaction with each of these former members.

RESEARCH AND PUBLICATIONS

The staff initiated the first comprehensive evaluation of our ten-year-old grants program. Without the assistance of our intern, Betsy Burr, this undertaking would not have been possible. Betsy developed a questionnaire which was mailed to each of the 119 grant recipients. The final response rate was 72 percent. Members of the Grants Committee met with Betsy to review the data and to discuss possible changes in application procedures, review criteria, publicity, program guidelines, and policy. The final report, presented to the Executive Committee, listed recommendations and outlined priorities based on current resources and staff time. As a result, the staff has already begun new program guidelines which are planned to encourage greater student participation in the grants program and to facilitate the review process.

Another project attempted to measure how active Council members have been in their contributions to arts programs at the Institute, in addition to their support of the Council. The results of this study were quite impressive. For every dollar contributed to the Council's operating budget by a Council member, another thirteen dollars, on average, is generated for arts programs at the Institute by Council members and through the efforts of Council members. These figures are based on the past four years and do not include estimates for gifts of works of art. Another parallel study will be initiated this year to assess those qualitative contributions to the artistic and educational life at MIT that are attributable to Council efforts.

A third research project, undertaken by Roy Lamson, is scheduled for completion next year. This comprehensive history of the Council's first decade will provide valuable information for our Council members and for our future planning efforts.

Council staff and members completed four publications this year. A new descriptive brochure, printed last summer, outlines the current Council operating structure, our services, and our programs. A third issue of *MIT Arts in the News* compiled press clippings reviewing MIT arts events and artists. Clippings ranged from the *New York Times* to the *Christian Science Monitor*, and from the *San Francisco Chronicle* to the *British Journal of Photography*. The staff also prepared a special printing of Robert Brustein's McDermott Award Lecture, "The Humanist and the Artist." A chronology of Council dates and events was compiled by Council Secretary Roy Lamson.

DEVELOPMENT EFFORTS

I wrote in this space one year ago that my first task as director would be to ensure sound financial footing for Council operations. Through reductions in personnel, new fund-raising strategies, and increased participation by Council members, we were able, for the first time, to raise 100 percent of our budget from Council members and friends, and to do so by the end of our fiscal year on June 30. Thus, we no longer require financial support from the Institute. This major breakthrough in Council financing would not have been possible without the dedication and perseverance of Gregory Smith, chairman of the Development Committee, who worked daily with Barbara Allen, assistant director. This year, 65 Council members provided direct support to the Council's operations, with an average gift of $2,250. This support was supplemented by gifts from 39 friends of the Council at an average of $1,150.

While important, the Council's operating budget is only one aspect of its development efforts. Members also contribute substantially to other arts projects and activities throughout the Institute. Over the past five years, Council members have contributed or assisted in raising almost $7.5 million in gifts and pledges for this $26 million Arts and Media Technology center. The Facilities Sponsoring Committee, under the chairmanship of Vernon Alden, has played a major role in raising these funds. Council members have also donated or loaned numerous works of art to the MIT Permanent Collection and the two Student Loan

collections. This year, these works included a portfolio of ten photographs by Barbara Morgan, donated by Ruth Bowman, and a selection of contemporary works on paper, donated or loaned by Lewis Cabot, Vera List, and Roger Sonnabend.

The staff also encourages direct sponsorship of arts activities by Council members. Among these gifts this year were an increase in music scholarship support by Ragnar Naess and a pledge by Solomon Manber to support the MIT student membership in Boston's Museum of Fine Arts for the calendar year 1984. Staff members have also increased their efforts to assist faculty and student organizations in raising funds from outside sources, including government agencies, foundations, and corporations.

PERSONNEL

Following the resignation of Elizabeth Scott, whose good humor and fund-raising talent contributed significantly to the Council, Barbara Allen was appointed assistant director. Barbara comes to the Council with extensive background in arts administration and the performing arts. Julian Low, a jazz guitarist, became the Council's new secretary. An intern from Wellesley College, Betsy Burr, worked with us for five months; we wish it could have been longer. Elizabeth Fox, a graduate of Colorado College, began research work as an intern to assist the Council's development program.

DEBORAH A. HOOVER

Vice President, Financial Operations

For the second year in a row the financial operations of the Institute were not in balance, with expenses exceeding income by approximately $3 million. However, there was no need to draw-down funds functioning as endowment, as funding was available from a reserve of investment income which has been built up over many years in order to have one-year's income in the bank, so to speak, in order to fulfill the commitments for the ensuing budget year. While this reserve is truly an income fund, it has been the practice in recent years to invest part of this reserve with the endowment pool in order that it might benefit from capital appreciation rather than investing it in short-term instruments of a fixed nature. Therefore, with the rise in the stock market during fiscal 1983, there was a substantial increase in the market value of this reserve. Thus, with the rise in the market value, it was possible to use part of the gains to finance operations from an income account rather than a capital account and at the same time preserve the policy of having in that reserve sufficient funds for approximately one-year's distribution. The Institute has long had a policy of investing on a total return basis but has deliberately refrained from basing its spending practices on a total return basis. Nevertheless, there is no particular feeling of restraint in drawing upon the gains in the income account which either have been realized or are currently realizable. In summary, it can be said on this point that while the financial operations were not in balance from a budgeting point of view, the actual results for the year along with the available gains in the income account brought the year to what is considered a satisfactory conclusion.

A further source of satisfaction as the year closed was the high degree of cooperation of the academic and administrative departments in refraining from spending their full allocation of resources for the year. This had a very positive effect on the deficit in operations which had been forecast in the budget process at a figure in excess of $4 million.

Nevertheless, the good results described above have not corrected the chronic imbalance which the Institute has had for years between recurring expenses and recurring income. With the continuing pressure to increase faculty salaries to maintain the quality of the faculty, with the constant pressure to introduce new programs, and the continuing need for facility renewal and upgrading, that chronic imbalance will persist and perhaps should be looked upon as a positive force in keeping the Institute where it is as a first rate institution. There are, however, two specific areas within the financial requirements of the Institute which have to be dealt with promptly. Both have been increasing at rates far greater than inflation and are probably not sustainable in the years to come. These are employee benefits and unrestricted funds available for undergraduate scholarships. Employee benefits have been growing by leaps and bounds in general and, more specifically, in the area of health care costs. There is a definite need to contain the total cost of the health programs as well as continuing reassessment of the sharing of those costs between the Institute and its employees. The area of undergraduate scholarships is now being addressed by a task force appointed by President Gray and the results of that study will soon be forthcoming.

Finally, another problem area which has become more apparent in the last year or two is in the field of financial systems along with the computer support which is required to make newer systems attainable and maintainable along with the flexibility required to meet changing conditions. Recent changes in the Federal tax laws alone created situations in which favorable implementation has been delayed because of the tremendous burden of adapting the current systems to the new conditions. The various problems which are being encountered in this whole area call for a special effort and seem to demand some change in the organizational structure to deal with them effectively.

The Federal-university relationship continues to be clouded by the indirect cost issues which have been raised by the Department of Health and Human Services. Their own failure to come up with acceptable solutions has led to the referral of the problem to the Office of Science and Technology Policy (OSTP) under the direction of the Science Advisor to the President, and hopefully much good work can be done in the coming months to put the indirect cost reimbursement problem in the proper perspective and still achieve resolution of what has become one of the thorniest problems in the Federal government-university relationship.

All in all, when all aspects of MIT's operations are taken into account, those in the financial administration feel that 1983 was a very fine year.

STUART H. COWEN

During the fall of 1982, a project was initiated to provide more detailed information for purchase order commitments on the monthly accounting statements. What appeared to be a relatively insignificant task, coupled with increasing demands from vendors for improved payment schedules, has clearly demonstrated the need for an integrated Purchasing/Accounts Payable computerized system. Several software packages have been investigated by the Purchasing Office and the Comptroller's Accounting Office. Our current effort is a first attempt at an integrated Purchasing/Accounts Payable System, taking advantage of the existing purchase order data base and paying function. This system, which will be partially available by late summer 1983, will give us the capability of tracking invoices through the approval and payment cycle and give more control over the clerical process. The next phase is a joint study to develop the functional specifications for a completely revised Purchasing/Accounts Payable System which should include laboratory supplies, inventory management, and billing in addition to a more efficient interface with Property Management.

During the fiscal year, most of the campus Exempt payroll population were reappointed to either the Research Staff or the Administrative Staff. Those individuals who elected to defer their reappointment option were transferred to the Lincoln Fiscal Office for paying purposes only. This allowed for the campus Payroll Office to eliminate the need and execution of the monthly Exempt computer payroll system. During the past year, work was begun on the conversion of the current stand-alone Student and Voucher Payroll System into the new and already functioning payroll system. A review of the original specifications and some changes thereto were completed and programming was started. Several other more critical tasks, however, have delayed progress somewhat; and, after completion of these tasks, we will redirect our efforts to the Student and Voucher Payroll conversion.

During the year, we installed an on-line computerized Travel Control System. The system has provided the office with better control over travel expenditures.

The Lincoln Laboratory Fiscal Office has continued its conversion of accounting and integrated them with those of the Purchasing Office of the Laboratory. A fully interactive operating system is evolving with the utilization of the IBM System 38 data base capability which has been expanded to a Model 4 with a 3370 disk drive.

In fiscal year 1983, the Audit Division was engaged in its continuing task of verifying that management policies and procedures are being properly implemented, that internal controls are being maintained, and that assets are safeguarded. Audits of departments and functions ascertain whether units are operating according to MIT guidelines and within prescribed contractual and budgetary limitations. Audits of administrative units determine whether internal control procedures are adequate and functioning as intended. Audits of inventories, receivables, and cash (or equivalent) evaluate the control and authorized use of MIT's assets and also determine valuations for annual statement presentations. These reviews and tests enable the Audit Division to identify and correct errors or omissions, to offer recommendations for improvements, and to verify implementation of findings and recommendations proposed by other groups performing reviews at MIT.

Personnel Changes

The following staff changes occurred during the past year: In February 1983, Edith A. Klotz was appointed staff accountant; and, in June 1983, Charles J. Ward retired after twelve years of service, Elizabeth M. Gallant was appointed staff accountant in the Lincoln Fiscal Office, and Mitchell A. Kloza retired from the Lincoln Fiscal Office after thirty years of service.

PHILIP J. KEOHAN

Office of the Director of Finance

Significant in the year's financial events was an inflation rate that was the lowest in ten years at approximately 4 percent, a substantial rise in the stock market, and an increased level of private support. In addition, the careful stewardship of the budget by the departments of the Institute resulted in almost all units ending the year with expenditures below authorized levels. While these events did not eliminate the deficit, they did allow substantial progress in the funding of future obligations, particularly for academic plant renewal and renovations, which were budgeted in future years.

Total operating expenses in 1982-83 were $588,702,000, an increase of 14 percent over the 1981-82 total of $515,428,000, Total operating revenues and funds used to meet these expenses rose to $578,382,000, an increase of 14 percent over the 1981-82 total of $505,941,000. The additional need for unrestricted revenues and funds required to bring operations into balance was $10,320,000 in 1982-83 compared to $9,487,000 in 1981-82. This requirement in 1982-83 was met in part from current year revenues of 1) $2,855,000 from the net Use of Facilities Allowance derived from sponsored research programs, 2) $455,000 from Patent Revenues, and 3) $3,904,000 from Unrestricted Gifts, Grants, and Bequests. These sources totaled $7,214,000.

The remaining need for unrestricted funds of $3,106,000 represents the shortfall between recurring revenues and expenses in operations. It is frequently referred to as a deficit and must be met by the use of Other Fund Balances or Funds Functioning as Endowment. In 1982-83 this shortfall was met by the use of an appropriate share of a special distribution from the reserve of Investment Income Held for Distribution to Funds. After the special distribution the market value of this fund as of June 30, 1983, was $36,800,000, an increase of $7,300,000 from its market value of $29,500,000 as of June 30, 1982.

One of the major factors contributing to the imbalance in operations is a planned program of renovations and upgrading of existing academic and research facilities. In 1982-83 $14,000,000 was expended in current operations for renovations, an increase of $4,600,000 from the 1981-82 amount of $9,400,000. These expenditures are primarily in support of new initiatives by the faculty. The Institute continues to keep the maintenance of its physical plant and equipment reasonably current and does not defer maintenance.

Operating expenses for instruction and unsponsored research increased by 12 percent over the previous year. The direct expenses of departmental- and interdepartmental-sponsored research increased 4 percent, and the direct expenses of Lincoln Laboratory increased by 27 percent. Much of the increase at Lincoln Laboratory is attributable to increases in sub-contracts and equipment purchases. The joint expenses applicable to instruction and research increased by 10 percent.

Total undergraduate scholarships in 1982-83 were $13,835,000, an increase of 25 percent over the 1981-82 total of $11,105,000. The unrestricted required to support these scholarships in 1982-83 was $4,704,000, an increase of 50 percent over the $3,131,000 required in 1981-82.

The Institute continued in 1982-83 its major effort in the expansion and upgrading of the educational plant. A list of the accomplishments in this area can be found in the Report of the Treasurer. The book value of the educational plant assets, including construction in progress, was $288,392,000 at June 30, 1983, up from $278,949,000 at June 30, 1982.

On March 17, 1983, $25,600,000 of Massachusetts Health and Educational Facilities Authority - Massachusetts Institute of Technology Series E bonds were sold at a net interest cost to the Institute of 7.12 percent. These bonds were sold primarily in support of renovations required by the Microsystems Technology Laboratory and the resultant relocation of the Information Processing Center. In addition, the bonds support the residential renovations in the Ida Flansburgh Green Hall, a residential facility at 350 Memorial Drive, and to the undergraduate dormitories on Ames Street, and for the rebuilding of the undergraduate chemistry laboratories.

Personnel Changes

The following changes occurred in the Fiscal Planning and Budget Office during the past year: William E. Kelley, Budget Director, retired after twenty-seven years of service to the Institute. Effective July 1, 1983, Robert M. Dankese, Associate Budget Director, will succeed Mr. Kelley as Budget Director. New appointments included Catherine Ormond and Karen A. Brehm as Budget Officers. Mary E. Gibson and Donna M. Ridewood were promoted to staff positions as Assistant Budget Officers.

JOHN A. CURRIE

Office of Sponsored Programs

For fiscal year 1983, the total volume of sponsored research performed on campus approximated $199,273,000, an increase of 3.8% over fiscal year 1982 volume of $191,970,000.

Of the major Federal agencies, only the level of research supported by the Department of Defense increased in real terms, as it did in 1982. The nominal increase in research funded by the Department of Energy resulted primarily from the growth of certain programs in the Plasma Fusion Center and the Laboratory for Nuclear Science. This partially offset the cuts in DOE fossil fuel and energy conservation programs, which had a significant impact on the Energy Laboratory in 1982 and 1983.

CAMPUS RESEARCH VOLUME BY SPONSOR

(in thousands of dollars)

	1968	1978	1979	1980	1981	1982	1983
Department of Defense (DOD)	17,285	13,694	15,223	19,183	23,011	27,429	31,883
Department of Energy (DOE)	9,841	32,338	42,005	50,004	49,562	46,283	48,271
Department of Health and Human Services (formerly DHEW)	7,843	18,855	22,061	25,320	29,175	30,911	30,870
National Aeronautics and Space Administration (NASA)	6,170	8,064	9,505	9,295	10,525	11,053	10,445
National Science Foundation (NSF)	7,073	21,832	23,469	25,055	29,913	29,776	31,003
Other Federal Sponsors	1,711	7,363	8,727	9,554	10,211	11,811	10,400
Total Federal Sponsorship	49,923	102,146	120,990	138,411	152,397	157,263	162,872
Industry	2,148	6,745	8,151	13,058	17,164	19,695	19,753
Foundations and Other Nonprofits	3,159	7,917	9,538	9,654	11,614	11,699	13,196
Other	598	2,466	2,627	1,999	2,795	3,313	3,452
Total Non-Federal	5,905	17,128	20,316	24,711	31,573	34,707	36,401
Total Research Volume	55,828	119,274	141,306	163,122	183,970	191,970	199,273

SIGNIFICANT DEVELOPMENTS

As in past years, a variety of continuing developments and new events had an impact on MIT sponsored research programs. Among these were the following:

Export Controls

In fiscal 1983, the issues involved in applying export control restrictions to teaching and research activities conducted by American universities were still unresolved. During the year, the Corson panel report (Report of the National Academies: "Scientific Communication and National Security") was widely distributed in the university community and the Federal agencies, and the joint University/DOD Forum was active as part of the DOD effort to thrash out its own policies and procedures. The report of the Ad Hoc Committee of the MIT Corporation on Information Transfer was accepted and approved by the Corporation, and the report of the MIT Committee on the Changing Nature of Information was completed and published. At year end an estimated 44 separate groups in 10 or more U.S. departments were studying the subject or

actually executing some aspect of policy; the OSTP study of scientific communication, part of a White House effort to develop a comprehensive policy on the export of technology with potential military applications, had been made part of a broader White House study of export controls; and the Congress was attempting to rewrite the Export Administration Act -- the key piece of legislation governing the export of critical technology -- which has been used to restrict communication of sensitive scientific information. Despite interagency feuding and deep divisions within the Administration, there was scattered optimism over the likelihood that, in the early months of 1984, a coherent, government-wide policy for the control of sensitive information might emerge.

Indirect Costs - Proposed NIH Reduction

For fiscal 1983, the National Institutes of Health had proposed that only 90% of negotiated indirect costs for research grants should be awarded, thereby resulting in an estimated saving of $70 to $80 million, with which NIH would fund new and competing renewal awards, but which would reduce otherwise allowable indirect cost recovery at universities and other grantee institutions by the same amount. After a dialogue between university presidents, Federal officials and the Congress, the House and Senate adopted Continuing Resolutions which provided funds sufficient to restore the 10% reduction and directed the Department of Health and Human Services to pay full indirect costs. Since then, NIH has proposed for fiscal 1984 other limitations which would result in similar underrecoveries of otherwise allowable costs. With the failure of the universities and NIH to reach accord on how to approach the problem, primary responsibility for resolving the issues related to indirect costs and to the containment of total biomedical costs, direct and indirect, has been shifted to the Office of Science and Technology Policy (OSTP).

Change in Indirect Cost Base

As anticipated in last year's report, fiscal 1983 was the first year of the conversion from a salary and wage base for the collection of indirect costs on OSP projects to a modified total direct cost base. Although the total allowable indirect cost reimbursement to MIT was not thereby changed, the distribution of indirect costs between individual projects and between laboratories and departments was in some cases significantly affected. Consequently, a substantial amount of attention was given to solving the transitional problems of programs experiencing unusual increases in indirect costs and in providing interpretations, in conjunction with the Comptroller's Accounting Office, as to how the new rules apply in a variety of situations.

Cost of Research Assistants

During 1983, MIT evaluated the impact and implications of a proposed change in the manner in which graduate student research assistants are charged to sponsored research grants and contracts. The decision was made to implement the change effective July 1, 1983, and a series of briefing sessions for faculty and administrative officers was conducted during the spring. Prior to the change, the tuition payments for research assistants were made from the student's salary, which was charged in full directly to the research project on which the student was employed. With the change, tuition payments are treated as an employee benefit and charged to the overall employee benefit pool, with the salary charged to the project thereby reduced by that amount. The principal effect is a reduction in the cost of a research assistant to the project from approximately $23,000 in 1983 to something approaching $15,000 in fiscal 1984, assuming a twelve-month appointment (with a relatively small increase in other project costs resulting from related accounting adjustments). This will make MIT research assistants comparable in cost to those at other institutions which have been using this approach, and will increase the incentive for principal investigators to use graduate student research assistants compared, for example, with postdoctoral research associates.

PERSONNEL CHANGES

During the year the following changes occurred in the Office of Sponsored Programs: Susan L. De Lyser transferred to OSP from the Health Sciences and Technology Division on November 8, 1982, as an assistant contract administrator; Robert L. Van De Pitte returned to OSP as an assistant director on January 1, 1983; Elizabeth C. Hurlbert, administrative assistant in the Security Records Office, was promoted from the exempt to the administrative staff as of February 1, 1983; David B. Foster, assistant contract administrator, left MIT to pursue a career in another area effective March 1, 1983; Heather D. Kraemer, assistant director, transferred to the Center for Transportation Studies as the administrative officer effective May 1, 1983; and George F. Prendergast returned to his position as OSP Coordinator on June 13, 1983, after completing an appointment at Boston University.

GEORGE H. DUMMER

STUDENT FINANCIAL AID OFFICE

The past year was a landmark year for financial aid. These annual reports, for a succession of many years, have pointed out a repetitive pattern -- a steady increase in the need for undergraduate financial aid, a less-than-proportionate increase in gifts and other resources designated for grants and scholarships, and a consequent disproportionately large increase in the amount of unrestricted operating income committed by MIT to the scholarship program.

Also evident in these reports has been the steady increase in the amounts of loans taken by MIT students to round out their grants and their families' resources.

Greatly concerned by the inexorable rise in both these important aid parameters, the President in September commissioned a Special Task Force on Undergraduate Financial Aid Policy, whose purpose has been to review the basis upon which financial aid is awarded, assess the Institute's ability to continue its present aid policies (both in relation to their cost to MIT and their impact upon its students), and to make appropriate recommendations. The final report of the Task Force has yet to be released, but in the course of its deliberations several years' worth of data was analyzed, assisting us to characterize the aid program more thoroughly than it has been for many years, and to make projections into the near future that would seem to bear a high index of reliability.

Grant Programs

Each year the contribution from students themselves and their parents rises a bit faster than the general inflation rate. However, the large increase in tuition, from $7400 to $8700, combined with the cost-of-living increases in other expense items (principally room rent and food costs) overshadowed the increased family resources and generated an increase in aggregate student need of 17 percent over last year. It has been the Institute's policy in the past to keep the increase in the job and loan portion of financial aid closely aligned with the cost of living. This past year marked a departure from the policy -- the "self-help threshold" (the loans/earnings expectation of aid recipients) was increased from $3400 to $4000, (a 17.6 percent increase, while the difference in CPI was only about 5.1 percent). Even so, the increase in need for scholarships and grants (generated by increased costs) outran the resources available, and it was again necessary for the Institute to devote a substantial allocation of unrestricted funds to scholarships. The past year's figure was $4,008,000, compared with $2,635,000 for 1981-82.

The government's Pell Grants program yielded predictably less, as the federal administration's planned tightening of eligibility rules steadily shrinks the program at MIT. The drop was 8.9 percent, from $870,000 to $795,000. The Supplemental Educational Opportunity Grants Program also experienced the expected 8 percent reduction, and provided $1,039,000 in 1982-83. On the other hand, the value of ROTC scholarships received by needy students rose 30 percent, from $641,600 to $832,000. Interestingly enough, the overall total of ROTC scholarships (including those received by students without documented need) dropped 10 percent. This probably reflects a new requirement that recipients formalize their commitment to active duty a year earlier than previously. These three federal grant programs yielded $2,664,000 for needy students, a 5.3 percent decrease from last year's level.

Other grant resources grew at more or less predictable, historic rates. About $3,292,000 was added to the scholarship endowment. Income from the endowment was up 7 percent, current gifts for scholarships up 1 percent, and direct grants to needy students from outside agencies (except for Pell Grants and ROTC Scholarships) were up 17 percent. In all, $12,319,800 of grants and scholarships, from all sources, was provided to undergraduates with need. The total amounts to 56 percent of the aggregate need.

Loan Programs

The Guaranteed Student Loan Program continued to lead all other sources in volume, at both the undergraduate and graduate student levels. But there was a shrinkage in the volume loaned under the program, traceable certainly to new eligibility requirements taking effect in the fall of

1981. The revised criteria themselves probably had a minor role in shutting students out of the GSL Program -- we suspect that broad publicity about the changes interfered with marginally eligible students' motivation to apply. Whatever the cause, volume fell 13 percent among undergraduate borrowers and 15 percent among graduate students. MIT continues itself to lend under the GSLP, and loaned a total of $322,580 in 1982-83 -- all to graduate students.

The National Direct Student Loan program continued at a level volume -- about $1,935,000 was loaned to undergraduates. The significant rise in the self-help threshold was expected to elicit an important increase in the level of requests for Technology Loan Fund assistance -- the "last resort" for students who desire to borrow their self-help expectation. We were ready to see an increase in TLF usage in the vicinity of $700,000-800,000; in fact, TLF lending rose by only $172,000.

Student Employment

Student earnings on-campus during 1982-83 increased 9 percent, partly reflecting an 11 percent increase in student minimum wage and partly demonstrating students' continued determination to earn a good proportion of their real educational costs. Heavy dependence on federal loan programs was still apparent among needy students, and overall the number of students working again remained constant.

The College Work-Study Program grant remained at its 1981-82 funding level, and went entirely to subsidize the on-campus student employment program. Approximately half of the total 1982-83 grant went to subsidizing undergraduate work, and half to subsidize graduate student teaching assistantships.

Prospects

The basic, authorizing legislation that describes the federal student financial aid programs expires in September of 1985. Next year, then, will be punctuated by intensified skirmishes among the many political and educational entities involved, as each maneuvers to gain the advantage. It will be a time for statemanship, and we eagerly anticipate the opportunities to be heard. What emerges will be the federal program for aid to higher education for the late eighties -- doubtless having a profound effect on the direction MIT's own program must take.

BURSAR'S OFFICE

Student Accounts

The new Bursary Payment Plan went into effect for the Fall Term. It assesses a finance charge in proportion to the unpaid balance of a student's account, compared to the previous fixed fee for deferred payments. The finance charge for the Fall Term was 1.25 percent monthly (15 percent annually), but was reduced to 1.0 percent monthly (12 percent annually) for the Spring Term as interest rates tended to moderate. The impact of this plan has been favorable. Monthly cash payments as a percentage of the net amount billed have been significantly higher than for the same periods last year.

Beginning with the Spring Term a new financial registration procedure was implemented. Under the old system, estimates of term charges were sent to students for their correction in advance of a later billing. The new system incorporates new term changes into the regular monthly statements; necessary corrections to this information are then made on subsequent statements. The change has resulted in substantial savings in mailing and printing costs and the general simplification of the financial registration process.

The Bursar's Office has been assigned responsibility for the follow-up and collection of delinquent student accounts, previously pursued by the Comptroller's Accounting Office.

General Comments

The procedures established in consultation with the Committee on Academic Performance (CAP) and on Graduate School Policy (CGSP) for the withdrawal of student status and the withholding of degrees from students who are financially indebted to the Institute continue to be successful. Eighty students were withdrawn from the Institute for financial reasons during 1982-83, compared with 116 students the previous year. And the number of students whose degrees were withheld this year dropped to 7 from 17 in 1981-82. Better communication between the Bursar and the academic departments, and the personal counseling of students by their account representatives have also contributed to this improvement.

In addition, through procedures worked out with the Registrar's Office, the registrations of students with outstanding balances from prior terms are being withheld until satisfactory arrangements are made for payment. This has helped to reduce substantially the number of students with past due prior term balances.

Student Loans

Student loan notes receivable amounted to $33.0 million at the close of the fiscal year, an increase of 5.4 percent. These notes are funded by $9,113,000 of MIT loan funds established by friends and alumni of the Institute, $17,280,000 of Federal funds in support of the National Direct Student Loan (NDSL) Program, $307,000 in funds borrowed from the Federal government to support our contribution to the NDSL Program, $2,000,000 borrowed from the Student Loan Marketing Association, $3,100,000 from a local bank, and $1,200,000 from Institute investments.

MIT established a Parent Loan Program (PLP) in 1977 to assist the parents of students receiving little or no financial aid in paying the cost of education. The program has grown each year and now totals 561 active accounts with an outstanding balance of $2,442,000. A total of $2,679,000 was disbursed during the year and the principal collected totaled $1,919,000.

Staff Notes

Maureen C. DeCourcey was promoted from Assistant to the Bursar for Loan Administration to Assistant Bursar for Loan Programs. Jeanne M. Burke was promoted from Administrative Assistant to Assistant to the Bursar/Control and Accounting. Judith F. Syatt and Cathleen M. Feeley were promoted from Administrative Assistants/Loan Collection to Assistants to the Bursar/Loan Collection.

JACK H. FRAILEY

Senior Vice President

This past year saw the completion of several major construction projects including Ida Flansburgh Green Hall, a new graduate women's dormitory on Memorial Drive located in the former medical infirmary; the Edward Pennell Brooks Center, a residence and conference facility in Dedham adjacent to Endicott House; the Plasma Fusion Center Tandem Mirror Facility housed in the former Nabisco Building on Albany Street; and the total renovation of the lower two floors of 50 Memorial Drive, the Sloan Building. Construction on three other projects was initiated: rehabilitation of the undergraduate chemistry laboratories on the fourth floor of Building 4; installation of kitchens and dining areas in the East Campus and Senior House dormitories; and conversion of Building 39, the former Computation Center, to house the proposed Microsystems Technology Laboratories.

The successful relocation of Computation Center activities from Building 39 to Buildings W91 (hardware and systems support) and 11 (user interface and consultation) is worthy of particular note. This intricate move, which was completed without major disruption of service, displaced about 100 persons and was accompanied by the replacement of existing major computing systems by two IBM 3033's, an IBM 4341, and a two-processor DPS8/70M Multics System. In addition, a Xerox 8700 Laser Printer was acquired to augment the existing Xerox 9700 unit.

This past year also marked the completion of the first year of operation under the Institute's plan for reducing administrative expenses by as much as 15 percent over three years. While efforts are being made to provide services comparable to prior years with fewer personnel, it is anticipated that future cuts in FY1984 and FY1985 will result in increased response time to emergencies and severe curtailment of weekend support services. Every effort will be made, however, to minimize actual effects on academic and research programs.

Following are individual department reports.

WILLIAM R. DICKSON

Campus Police

This year was a significant one for the MIT Campus Police. It marked the department's 25th anniversary of providing professional police and emergency medical service to the MIT community. In addition, a record low was set for overall incidents of crime on campus, while requests for services such as medical transports and after-hour escorts continued to rise.

In keeping with the recent national decrease in crime, the 1,945 complaints received by the department were down 8 percent compared with last year. Of these, 23 were in the crimes against persons category, with the most common complaint being assault and battery. Although one incident of rape was reported, overall, serious crime on the MIT campus was down 21 percent over the previous year.

Larceny continued to be the most frequently committed crime on the campus; however, the overall total dollar losses recorded in the categories of Institute property, personal property, and residence hall theft were down significantly. Institute property losses for the year totalled $31,849, a decrease of 40 percent over last year. Personal property (non-residence) losses were down 31 percent and residence hall losses dropped 53 percent. The drop in losses is believed attributable to the department's annual crime prevention measures.

This year's total of 37 stolen vehicles matched the ten year record low recorded in 1980-1981 and was down 14 percent over last year.

Bicycle theft, which rose each year from 1978-1979, dropped significantly to a total of 44 stolen bicycles, a 57 percent decrease over last year.

One of the two major service categories which continued to rise during the year was emergency medical services. An increase of 18% in ambulance runs was recorded by police emergency medical technicians. A total of 2,556 emergencies, transfers, or medical shuttles were performed.

In another heavily used service area, the number of escorts performed by the Campus Police continued to increase steadily. A total of 11,543 escorts were conducted during the year, a 24 percent increase over the previous year.

Campus Police officers logged the second highest number of arrests in departmental history with a total of 127.

The Special Services Division continued to provide a wide range of specialized assistance to faculty, staff, and students in the areas of crime prevention, consumer and legal affairs, and criminal investigations.

The department looks forward to continuing to provide the MIT community with professional police and emergency medical services in the coming year.

JAMES OLIVIERI

Child Care

The demand for child care on campus continues both for infants and toddlers as well as for pre-school children. A waiting list for center-based care existed throughout the year and more requests than usual were received for a combination of center and family day care. During the year, the Child Care Office served the many needs of the MIT community for child care information and referral. Family Day Care, the home based system, increased its off campus provider group to offset the loss of several on campus providers. The Child Care Office staff visits all licensed homes on a regular basis and lends support to providers and users. A closer working relationship has been developed between the Child Care Office and Technology Children's Center, Inc. in order to better utilize the services and resources within the Institute.

Technology Children's Center continues to offer center-based care for children from 2 years, 9 months to 6 years in four classrooms in the Eastgate and Westgate apartment complexes. Over 100 children participate yearly in the programs designed to promote social, emotional, and intellectual skills. The extensive playgrounds provide an opportunity for imaginative play and gross motor development for children enrolled in the Center and in Family Day Care as well as for children of residents. The Center encourages the informal participation of parents in the program, such as providing the opportunity to eat lunch with the children, accompanying a group on a field trip, or serving on the Board of Trustees.

Although the number of students entering the field of education has decreased, the Technology Children's Center continues to serve as a field placement site for several colleges and universities in student teaching and administration. With the increased interest in employer-supported child care, MIT's child care facilities receive frequent inquiries. The classrooms and playgrounds are frequently visited by interested persons from this country and from abroad.

LUISE FLAVIN

Endicott House

The highlight of the year was the Dedication of the Edward Pennell Brooks Center at Endicott House and the Carol Wright Brooks Garden both on May 27, 1983. Mr. Brooks and 23 members of his family spent two nights in the new facility bearing his name.

Endicott House and Brooks Center were used 257 days and 175 nights during the year. There were 37 resident conferences held compared to 27 the prior year, with a sharp increase in resident business occurring during May and June. Of these 37 conferences, 23 were MIT groups compared to 14 last year. Throughout the year, 133 non-resident groups used the combined facilities. Of these, 91 were MIT groups, a slight decrease from the prior year.

A new record was set for the month of June, with eight resident groups and 31 non-resident groups being accommodated.

Since the Brooks Center opened on February 25, 1983, it was in use 52 days for day meetings and 26 nights for resident groups.

AIMEE PIERSON

Graphic Arts and Audio Visual Services

After six consecutive yearly increases, the dollar volume of business at Graphic Arts Service declined this year with total revenue being approximately 7 percent less than last year. The reason for the decline can be attributed to Institute-wide budget restrictions.

The Offset Printing section and the Illustration Department were particularly hard hit as a trend developed toward the utilization of more simplified forms of presentation materials in an effort to minimize departmental costs. It is expected that this trend will continue in the years immediately ahead.

The renovation of the basement of the Sloan Building, which forced the Building E52 Copy Center operations to move to Building E51 for over a year, was completed in March 1983 thereby enabling the Copy Center to return to brighter, larger, and more efficient quarters.

New equipment placed in service during the year included a Kodak 250AF copier in the Building 3-003 Copy Center; larger, more efficient, and better quality copiers in the Copy Centers of Buildings 1, 2, 13, and E52; and a new A & M digitized typesetter in the Typesetting Department at the main office.

JAMES W. COLEMAN

Housing and Food Services

MIT's first residence for single graduate women opened in February upon completion of renovations to the building which formerly housed the medical infirmary. It provides accommodations for 45 women in a variety of singles and doubles, with lounge and kitchen-dining facilities on each floor. This residence, Green Hall, was dedicated on June 10, 1983 in honor of Ida Flansburgh Green of Dallas, Texas, who has long been a friend and benefactor to women pursuing graduate studies at the Institute.

Implementation of the East Campus-Senior House residents' proposal to install kitchen-dining facilities in these houses is well underway, with completion expected by the end of summer. With these facilities, 17 units in the two houses, the residents will not be required to participate in the commons program next year.

Energy rebates were made to all campus residents again this year since the unit price for energy was lower than projected.

Nearing completion is the program to install smoke detectors in all dormitory rooms and apartments. This effort, conducted by the Safety Office and the department, was required to meet new city and state fire safety codes.

The dining program completed its last year of transition. Next year, all four classes will participate in the commons program. We continue to make changes in menus and service, where possible, attempting to meet the ever-changing needs of students. The contributions of the House Commons Committees, Dining Advisory Board, students, and employees are greatly appreciated.

A new food service facility was opened in February on the first floor of the Sloan Building. This unit, operated as an adjunct to the Faculty Club, serves light lunches, snacks, and beverages Monday through Friday. It has been well received by the community and averages approximately 700 customers each day.

There were 7 persons with a total of 174 years of service who retired from the department this year. Mr. Joseph DiNapoli served as a cook in Walker Memorial for over 43 years. Mr. Robert Shaw, Assistant Director, Housing, retired after 36 years with the department.

HARMON E. BRAMMER

Information Processing Services

Summary of Activities

As Director of Computing and Telecommunication Resources, my major activities have been oversight of all MIT computational services and centers and guiding the campus computer network development effort.

Because of restructuring of Institute administrative responsibilities during the year, on January 1, I began reporting to William Dickson, Senior Vice President, instead of to the Provost, Francis Low. On July 1, my responsibilities will be taken over by James Bruce in the newly created position of Director of Information Systems.

The more significant events during the year have been:

1) The exodus of the information Processing Services from Building 39 (to make way for the VLSI Center) to Buildings W91 (hardware and systems support) and 11 (user interface and consultation). This intricate move, which had to be carried out without significant interruptions of service, displaced around 100 persons and was accompanied by the replacement of the major computing systems by two IBM 3033's, an IBM 4341, a two-processor DPS8/70M Multics System, and an additional Xerox 8700 Laser Printer to augment the Xerox 9700. In addition, the Student Information Processing Center has been relocated to Building 11.

2) Participation in the planning and formation of Project Athena, a five year experiment involving the intensive introduction of the use of individual workstations into the Engineering Curriculum and a de facto required introductory computation subject taken by all undergraduates.

3) Coordinating and guiding the evolution of the Campus Computer Network. This activity has now matured to the point where the formation of a budgeted permanent maintenance group has been recommended. The major activities during the year have been extending the current network to include the School of Engineering, Joint Computing Facility, and the Laboratory for Nuclear Science; beginning a central network mail address directory; and experimenting with line-concentrating multiplexors and microwave links in support of the SIPB terminal pool room in the Student Center. Particularly important contributions were made by members of the Network Working Group.

FERNANDO J. CORBATO

As of June 1, the department successfully completed its relocation from Building 39 to our new locations in Building W91 for hardware and systems support and to Building 11 for user interface and consultation.

Although the relocation was a trying experience for the staff, the users experienced a minimum amount of inconvenience. Benefits gained as a result of the move include improved public terminal facilities, upgrades of both the Honeywell and IBM computer hardware and a generally more convenient location of user services.

From a computing hardware standpoint, the administrative computing resources were upgraded from an IBM 4341/L1 and IBM 4341/M2 to an IBM 3033N-12 and 4341/M2, resulting in an overall Central Processing Unit (CPU) increase of 170 percent. The academic and research computing power increased by 92 percent when the IBM 370/168 was replaced with an IBM 3033N-12 and the three-processor Honeywell 6180 to a dual-processor H870M. These changes have resulted in improvements in response time at the user terminal level as well as in turnaround for batch processing runs. Also, costs for academic and research users have been, in general, lowered.

Administrative Information Systems

With the move of the administrative systems to new hardware with new telecommunication connections for all on-line users, we were able to capitalize on this transfer and improve our security by eliminating the sharing of disk files with the academic community. In addition, we took this opportunity to standardize our routine system utility functions and integrate our operational procedures with those already established serving the academic and research users.

For the past several years, we have been developing new systems in an on-line interactive mode using the ADABAS data base management system. As we entered 1983, we had few production management services in place to meet the needs of this new semiautonomous user group. During the year, we concentrated on developing a production services hotline for problem reporting and questions; an Administrative Network Support Group to assist clients with equipment planning, acquisition, installation and maintenance; and a Data Base Support Group establishing standardized backup, recovery, diagnostic and archiving procedures.

In the Systems Development area, a major portion of a new Personnel System was completed along with a Travel System and a prototype Financial Data Base. Production support procedures were established for the turnover of the Hourly and Support Staff Payrolls, the Alumni System and Undergraduate Admissions. Development continued on the Pension Accounting System and the needs analysis of the Physical Plant Operation. Our Documentation Group achieved major accomplishments during the year in reducing what had developed as an overwhelming backlog of documentation on our new systems activities.

In October 1982, the Institute selected Digital Equipment Corporation and Philips/MICOM as the recommended suppliers of word/text processing. This decision was a result of an in-depth analysis of hardware/software suppliers and the needs of MIT's academic and administrative departments. Since that time, departmental personnel have arranged for equipment demonstrations, provided vendor liaison, configured hardware, assisted in installation and testing, arranged for introductory classes of instruction, and provided individualized consulting and training. During the year, 110 DEC DECmates and 9 MICOMS were installed on campus.

Use of the Xerox 9700 laser printing system was exploited more heavily during the year as we not only converted a number of preprinted forms to standard 8 1/2 by 11 format but were able to generate camera-ready copy of computer output with varying type fonts to meet the needs of the Registrar for the graduation book and for our Student Financial Aid Office for applicant letters.

Systems Programming

Most of the interesting developments in the systems programming area concerned telecommunications, a field which has become nearly as important as the computer systems themselves.

In conjunction with EDUNET, we have been implementing an inter-university electronic mail system called MAILNET. This system allows each school to continue to use its own mail system while extending their capabilities to allow them to send and receive mail with other shcools in the network. This is accomplished by having the Multics system act as a postman by dialing up, logging in, and picking up and dropping off mail at each computer in a round-robin fasion. MIT joined another inter-university mail network called BITNET. This system takes advantage of already existing software on the IBM/VM system and required only the addition of a communications link to another node on the network--in our case, Boston University.

Other activities of interest were upgrading our IBM operating system to VM/SP2, IBM's newest release; the installation of a highly modified version of CMSBATCH; the implementation of a routing system necessitated by the addition of another on-campus high-speed printer in conjunction with our move; and the addition of a second IBM Series 1 to handle the increasing demand for full-screen capabilities on ASCII terminals.

Academic and Research Computing Services

During the year, we converted to the new ANSI'77 FORTRAN compiler on our IBM system. Other new software packages added included MATLAB, an interactive numerical subsystem involving matrix manipulation; two graphics systems, the Tektronix Interactive Graphics Laboratory and SURFACE II, a contour plotting package; IMF International Financial Statistics data archiving facility; and updated versions of BMDP, NAG, and FOCUS.

A major change in staff consulting was adopted during the year with the staff reduction made at the beginning of the year. "Walk-in" consulting was allocated to student employees under the direction of one staff member and in-depth consulting on an appointment-arranged, chargeable basis. As a result, we were able to better utilize staff time on assigned projects, minimize the cost of trivial consulting, and maximize the delivery of in-depth consulting in such areas as statistical and numerical computing and database management systems.

During the year, we saw an increase in contract programming, consulting, and training work. Projects are now underway with the Aga Khan Program for Islamic Architecture; the design and teaching of an intermediate CMS course for Administrative Information Systems; a PL/I course for the Visible Language Laboratory; and a CMS and FORTRAN course for the NAVAL post-graduate program in the Department of Ocean Engineering.

Utilizing the Xerox 9700 laser printer, the "COMPOSE" text formatter on Multics, and some special tools developed in-house, we were able to publish seven new titles in our documentation area: MATLAB at IPS, Multics Word Processing Using Compose, PL/I at IPS, PL/I Study Guide, SESAME and DATAMAT at IPS, Tapes on VM/SP, and Word Processing on CMS. In addition, we were able to completely revise the TROLL Reference Guide, an effort that was done in cooperation with the Center for Computational Research in Economics and Management Science.

With the increase in micro computers on the campus, effort was exerted in several areas to address issues relating to the interaction of these machines with the central facility.

From a networking standpoint, 1983 has seen a significant increase in the use of networks, both public and private, to access our computing facilities. Because of this, we have significantly upgraded our on-line documentation for network access via ARPAnet, TELENET, TYMNET, ChaosNet, BITNET and Mailnet. Conversion to the X.25 protocol on both commercial networks (TELENET and TYMNET) on the Multics system has been completed, although conversion of the IBM system to X.25 is yet to be accomplished.

WESTON J. BURNER
JEAN C. BONNEY
JOSEPH R. STEINBERG

Office of Facilities Management Systems

Facilities Management

The Office of Facilities Management Systems (OFMS) is responsible for the collection, maintenance, and reporting of data for more than 24,200 individual spaces at MIT, comprising 7.4 million net usable square feet. Using INSITE 3, an MIT-developed space accounting system, two major updates to the space inventory were completed, each followed by the distribution of standard reports to academic and administrative offices. Numerous special reports were also requested throughout the year. Also, historical facilities data were updated and distributed in graphic and statistical form, and the Building Data Report was again updated and distributed. Additionally, a filter monitoring application for Physical Plant, using the INSITE system, was designed and implemented. Training of that department's data manager was also provided.

INSITE Consortium

Joining the Consortium this year were AVCO, Memorial Sloan Kettering Cancer Institute, and the University of Alaska. All members employ the INSITE system and its associated methodology both to manage their inventories of building space, as well as to share their knowledge and experience in this area with MIT.

Support activities peaked again during the year in the forms of telephone contacts from members, visits by departmental staff to members' sites, the conducting of six training courses, the publication of a quarterly newsletter, and the record attendance of Consortium members at the 3-day 11th Annual Conference at MIT. A 2-day course in Facilities Management for Senior Executives, available to non-INSITE users, was presented twice this year.

Property Management

During the year, more than 15,000 newly acquired items of movable equipment were identified and tagged with bar code labels. An inventory of existing items of movable equipment continued and approximately 55,000 items were identified and appraised. Over 200 final inventory reports pertaining to contracts and grants were prepared.

Almost $2.3 million (original acquisition costs) of excess Federal government equipment was acquired, along with $176,000 of surplus State equipment. Also, items of equipment and materials were acquired from the National Association for the Exchange of Industrial Resources and from other private sources.

Approximately 1,150 items with an acquisition value of $410,000 were transferred from one MIT department to another for reutilization. Almost $120,000 of equipment unneeded or unusable by the MIT community was sold. A typewriter reutilization program was begun whereby typewriters, which were going to be traded in, were turned over to OFMS for their trade-in value. The typewriters were then sold to other departments or to private individuals. During the first year of this program, 131 typewriters were turned in of which 40 have been sold to departments and 52 sold to individuals. Most of the equipment available for reutilization or sale continued to be displayed at the MIT Equipment Exchange.

In conjunction with the Society for Property Administrators, OFMS was responsible for presenting a Property Management Seminar at MIT. More than 150 attendees from the United States and Canada were present at the seminar. A newsletter was published for the nearly 300 Society members.

Arco Grant

The first of two phases of a grant from the Atlantic Richfield Company (ARCO) was received to develop a computer-aided drafting (CAD) system to be linked to the INSITE system.

KREON L. CYROS

Physical Plant Department

The department completed its first year of reduced operations in response to the Institute's three year program to lower substantially the cost of support services. While efforts are being made to provide comparable service with fewer personnel, response time to emergencies will be longer and weekend support services will be severely limited. The last two years of the program will result in further reductions or elimination of some services to the community. Every effort will be made to minimize actual effects upon academic and research programs.

Building Services and Maintenance

The custodial training program administered by the department continues to provide cost benefits in times of reduced staff and frequency of cleaning. By constant training and retraining, we are still able to maintain a high level of employee performance in spite of operating demands which have increased steadily over the years due to the growth of the physical facilities of MIT.

We are having difficulty insuring an adequate frequency for the painting and door preventive maintenance cycle. While we are trying to track the status of these elements with computer programs, we have been unable to reduce backlogs of required work with current staff levels. Systematic evaluation and funding of deferred work continues to be the goal of the department.

Building Operations

This year, a training program was initiated for both the service and administrative staff to increase our ability to deal with equipment dispersed throughout the campus whose age and complexity have established new requirements for service in times of diminishing financial and personnel resources. Hourly training has focused on technical subjects both in the mechanical and electrical areas. The topics selected were developed from a formal needs analysis coupled with a continuing assessment of employee skills. The core of the supervisory training was a packaged course entitled, "Maintenance Management for First-Line Supervisors", taught by the Building Operations Superintendent. The course includes units on the Supervisor's role in maintenance management, labor relations, improving performance, spoken and written communications, etc.

We have continued the expansion of our second-generation energy management system and now have 44 unit controllers (microprocessors which replace pneumatic controls in a building) installed in 16 additional buildings.

Utilities and Engineering

Level energy prices and a continuing active concern for energy conservation held the Institute's energy cost increases for the year to those associated with the increase in campus facilities due to construction and renovation. A pattern is emerging on the use of utilities in our research intensive buildings which gives us concern. The current direction of our research programs seems to be toward much higher use of electric power and air conditioning for each research dollar than was true in the past two decades. This trend is typified by the proliferation of laser research, wet laboratory life science research, expansion of the complex area of micro-chip research, and very rapidly expanding utilization of computation equipment -- now in the administrative office and student room as well as in the research laboratory.

The plant has begun to address these energy concerns with the resources of the energy conservation program and shift some emphasis from the Building Energy Audit and Modification (BEAM) Program of building system modification. The BEAM program has reached a plateau with the completion of the modifications of the first group of most energy intensive buildings and a carry on program for the next group of modifications is under consideration with the possibility of innovative financing and turn-key package renovation.

The plan received some tangible recognition from outside the Institute community this year for performance in the energy conservation area. A unique energy conservation device developed at the Institute under plant auspices was selected as a winner in the annual NACUBO/USSF Cost Reduction Incentive Awards Program. The device which provides, at low cost, a selectable low-speed position for the electric motors driving pumps or fans in building environmental systems, is in place in two MIT buildings and is providing a less than two year simple payback through reduced use of electric energy.

A major change in utilities operation was accomplished by arranging the controls for the East Campus Chilled Water Plant so that the plant can be remotely operated from the Central Utilities Plant. This was done through the existing campus Facilities Control System (FCS) and five microprocessor unit controllers located in the East Campus Plant.

Architecture, Engineering & Construction

A number of major projects were completed and occupied during the year including: Ida Flansburgh Green Hall, a new graduate women's dormitory on Memorial Drive in the former infirmary building; Edward Pennell Brooks Center, a residence and conference facility in Dedham adjacent to Endicott House; renovation of the lower floors of the Sloan Building on Memorial Drive; and the Plasma Fusion Center Tandem Mirror Facility in the former Nabisco Building on Albany Street.

Projects under construction are the EG&G (Edgerton, Germeshausen and Grier) Education Center adjacent to the Fairchild Electrical Engineering Building to be completed this summer, the Arts & Media Technology Building on Ames Street scheduled for completion in the Spring of 1984, and the complete rehabilitation of the undergraduate chemistry laboratories on the top floor of Building 4, scheduled to be completed for the 1983 fall term. Also scheduled for completion in the fall is a sizeable project to install kitchens and dining areas in the East Campus and Senior House dormitories.

The first phase of the Microsystems Technology Laboratories project which involved the vacating of Building 39 to make way for construction of the new facility was successfully completed in May 1983. The Information Processing Services' computers were moved to renovated space in the former Supersonic Laboratory on the West Campus. Computer user services and administration were moved to renovated space in the former medical department area in Building 11 and Building 4, while the Industrial Liaison Program was consolidated on two floors of the Suffolk Building on Main Street. All these moves were made without interruption of extensive computer services.

Projects in the design phase and scheduled for a construction start this summer are the Microsystem Technology Laboratories facility in the vacated Information Processing Services Building, renovation of the upper floors of the Sloan Building, major renovation of 175 Albany Street to accommodate the Nuclear Magnetic Resonance (NMR) facility and Plasma Fusion Center activities, and the renovation of the remaining space in Building 11 to house the Joint Computer Facility and Project Athena on the first floor and the Graphic Arts Copy Center in the basement.

Administration and Telecommunications

During the year a needs study was initiated to determine the management information requirements of the department. The study involves interviews with plant managers and Institute community users of plant services and researching available software packages and possible hardware support equipment. When the study is finished in the fall, we will seek approval for replacing our 10 year old data processing system.

MIT has entered into an agreement with the New England Telephone Co. (NET) to retain the present Centrex (CTX) system until February 1986. During the life of the agreement, monthly rates for most central office originated services will be stabilized, providing MIT a measure of rate stability for telecommunications services.

For the longer term, we have started preparing a request for proposal which will be issued to selected vendors or suppliers in late 1983 or early 1984 for a system to replace the present CTX system by mid-1986.

A program to replace 3,500 NET provided single-line telephone instruments with MIT-owned devices was initiated in late February 1983 and so far, approximately 500 such telephones have been replaced. A similar program to replace multi-line telephone instruments continues with some 500 units replaced to date.

The Telecommunications Office message center has replaced its stand-alone equipment (i.e. one machine for Telex, one for TWX, etc.) with a microprocessor multifunctional system. The most important improvement in service to MIT users has been the introduction of electronically originated messages. For those with data terminals or word processors with communication capability, it is now possible to send and receive international Telex messages without leaving their offices. This is done through a standard electronic mailbox on the Multics mail system.

The number of outgoing Telex/TWX messages in 1982 was 10,133 (a 12 percent increase over calendar 1981). The number of incoming messages is slightly greater. The message center now handles 9,700 facsimile messages annually, two-thirds of which are outgoing.

A small microprocessor telephone switching system was purchased and installed for the newly constructed Brooks Center in Dedham. This new system provides room telephone service to program participants both in Endicott House and the new facility.

PAUL F. BARRETT

Planning Office

During the year, the Planning Office undertook a broad range of land, housing, transportation, academic facilities, campus environs, institutional research, real estate development, community planning and zoning projects. Working within the context of the fiscal constraints that have been the dominant theme at MIT this year, we have focused our planning perspective on planning issues that lie beyond the budget cycle. We have found that there are many new constraints ranging from land to demography that will influence the Institute's future options. Some of these have provided the basis for our activities this year.

Our report on land resources, available to MIT for academic and related purposes, indicates that the Institute faces some serious problems in the future as it seeks to provide for new facilities and off-street parking as required by the ordinances of the City. While progress was made in fulfilling some of the objectives of the campus housing plan with the completion of renovation of 350 Memorial Drive for a graduate women's residence, any major additions must await the availability of additional land for student housing. Work has continued with the administrative housing group on the development of a plan that would meet some of the needs of our faculty and staff for housing near the campus. Transportation planning continues to be a major component of our work. A continuing appraisal of our off-street parking requirements, the development of a management information system to ensure that we are making the most effective use of our parking resources, and the development of a commercial parking lot to meet some of the MIT visitor requirements were major elements of our work efforts this year. In addition, work along the MBTA's Red Line, and in particular the Kendall Station, has required our careful design review. It appears that the reconstruction of the Kendall Station will begin in the fall of 1983. The full impact of these changes will not be known for two years, but it is clear that with the growing development of commercial facilities in Kendall Square and surrounding areas, combined with the City's effort to control the use of on-street parking, that transportation planning will continue to be a major issue for us in the year ahead.

Planning for academic facilities this year included studies of space needs in the Humanities Department, a review of the facilities plan for the Physics Department, the Arts and Media Technology Project, the (VLSI) Microsystems Laboratory, the relocation of the Information Processing Center, continued development at NW17 and NW21 on Albany Street for the Plasma Fusion and Magnet Laboratories, and continuing studies for new facilities for the Computer Sciences and Artificial Intelligence Laboratories.

With the completion of a number of major capital projects in recent years, need to revive and accelerate our campus landscape program has become more apparent than ever. We have, this year, sought to resolve a number of outstanding operating problems in the Eastman/McDermott Court area that would provide for a safer, vehicle-free environment in the vicinity of the East Campus houses and in those courtyards. We have revived and updated the Amherst Alley landscape plan which would provide for a considerably safer and more attractive pedestrian way to and from the west campus.

A number of institutional research projects this year highlighted MIT's use of hotel services in the Boston-Cambridge area and ways in which MIT's purchasing power could be used to gain more effective discounts for Institute-related hotel users. A study of the MIT Faculty Club's operations and facilities was undertaken for the Housing and Food Services Department. A study of student cross-registration between Harvard and MIT indicated a number of ways in which the two institutions could more effectively balance the demands on resources generated by cross-registration. In recent years the balance has shifted to more Harvard students taking courses at MIT than was the case in the past. At the request of the Harvard Cooperative Society, the Planning Office prepared an analysis of the MIT community's disposable income patterns and service needs and presented these at a meeting of the Harvard Cooperative Board this spring. This should assist the Board and its management in finding more effective ways to meet the MIT community's retail service needs. Finally, the Planning Office has begun to explore the implications of the Institute's changing demography in order to ascertain what impact there will be on the community of a significantly older population remaining for longer periods of time and their needs for services and facilities in the future.

Community planning continues to be a significant element of the Office's activities. We continue to work with the Massachusetts State Historic Commission on questions involving MIT's principal buildings, and with the City of Cambridge regarding the Institute's development for academic land use, housing, and transportation. Our investment real estate activities continue to be a major focus of our activities, and they involve principally the development of the former Simplex property.

The emerging planning issue that will form the agenda for the future will, in all probability, be drawn from the five-year plans requested of all academic departments this year by the Office of the Provost. These projections, along with the natural demographic trends within the existing community and the physical limitations that are a result of our physical location and the political climate in which we live, will be the ingredients for a challenging planning agenda for the future.

O. ROBERT SIMHA

Purchasing and Stores

Major projects accomplished or initiated this year included:

1) The establishment of an automated, on-line Authorized Signature File at the General Purchasing Office for screening incoming requisitions to verify approval signatures. The on-line system will also be used for this purpose at the Office of Laboratory Supplies, Graphic Arts, and Physical Plant, and at the Comptroller's Accounting Office to verify approval signatures on invoices and request for payment and travel forms. With additional on-line computer capacity, other Institute locations which have need for signature authorization information will be able to access this system. The system will become operational during July of the coming year.

2) A Purchasing Task Force was convened by the Senior Vice President to review suggested centralization of certain of the purchasing functions performed by the Department of Purchasing and Stores and the on-campus laboratory purchasing agencies. Centralization was suggested by the Director of Purchasing and Stores in a strategic planning document which proposed significant reorganization and consolidation of the involved purchasing offices and agencies in ways in which strengths would be maximized, essential services would be maintained at adequate to high levels, the mechanics of procurement would be improved, and overall operating expenses would be substantially reduced. The Task Force was charged with endorsing the Director's strategic plan or recommending an alternate plan which would be cost effective and would maintain essential services at high levels. Task Force recommendations are expected in August of the coming year.

3) As part of an ongoing effort to streamline invoice processing, and with the introduction of accounts payable automation, the person and automated functions established at the General Purchasing Office for the receipt and initial processing of invoices were transferred to Accounts Payable of the Comptroller's Accounting Office.

4) A listing of the sources from which MIT people could purchase their own personal computers, accessories, and software at discount prices was compiled and distributed by the General Purchasing Office to many interested members of the community. A considerable effort was required to locate sources willing to sell directly to individuals at discount, and to negotiate best discounts and uncomplicated purchase procedures.

5) Representatives of the Department of Purchasing and Stores and the Comptroller's Accounting Office have met regularly on the matter of improving and transferring automated accounts payable functions to equipment which is common with the equipment on which the automated purchasing commitment recording and reporting system operates. The union of Accounts Payable and Purchasing on common equipment should result in far greater efficiency, and will be the forerunner of fully automated purchasing/accounts payable functions with interface and access capability available to other administrative offices and systems, and, with sufficient on-line computer capacity, the on-campus departments, laboratories and centers.

General Purchasing Office

Purchasing activity for the year continued at the previous year's level. Major emphasis continued to be placed on negotiating discount agreements with suppliers on the basis of total business, Institute-wide. Automation, which is available at the General Purchasing Office and at the Purchasing Office at Lincoln Laboratory provides information required for negotiating on a total business basis.

Office of Laboratory Supplies

Combined sales of office and laboratory items and furniture and furnishings increased 7.2 percent over the previous year (excluding previous year sales of furniture and furnishings related to the opening of new buildings). On this basis, sales of office and laboratory items increased 2.5 percent and sales of furniture and furnishings increased 23 percent.

Efforts to reduce the price of purchased goods continued to result in meaningful reductions in pricing through competition and negotiation.

Minority/Women Owned Business Purchasing Programs

Business placed Institute-wide under these affirmative action procurement programs resulted in the award of over $3.75 million of our business to minority and women-owned business concerns. Over $1.8 million was awarded to 185 minority businesses and over $1.9 million was awarded to 490 women-owned businesses.

BARRY M. ROWE

Safety Office

Training was a highlight of Safety Office activities this past year. Although always a part of the Safety Program, this year more formalized programs were developed due to government regulations such as OSHA's Emergency Action Plan program. Over 120 Emergency Action Plan program coordinators met and were presented with a program for development during the year. Laboratory workers met on campus and at Lincoln Laboratory to discuss new hazardous chemical labeling systems developed by major chemical suppliers.

Supervisors on Campus and at Lincoln Laboratory continue to receive instruction on Workers' Compensation claims reporting which has helped to better manage costs and more efficiently administer this program.

Laboratory Safety

New audio visual equipment and associated films and slide tape materials purchased during the year have played a major role in safety presentations primarily to the departments of Biology, Chemistry, Chemical Engineering, Medical, and Lincoln Laboratory.

The volume of waste chemicals increased by 21 percent over the previous year. A red tag system for identification of waste chemicals has been established to avoid confusion with ordinary rubbish.

Safety review of laboratory renovations continues to result in upgrading of spaces. The 4-440 Undergraduate Chemistry laboratory renovation was the major space changed reviewed.

Education and Training

Twenty-one CPR and four first aid courses were given involving 252 persons in 15 laboratories and departments on campus. At Lincoln Laboratory, 1 first aid and 21 CPR courses were given involving 205 persons. Safety seminars were a major activity with the departments of Materials Science, Chemistry, Biology, Physics, the Magnet Laboratory, and Lincoln Laboratory all participating.

A rigging seminar is being developed by our insurance carrier for personnel at the Plasma Fusion Center. Several supervisors took part in an instructors' course for defensive driving techniques.

Fire Protection

A program was initiated for live testing of fire alarm warning devices. A sample of the buildings tested were 10, E17, E18, E19, and Endicott House.

A permit system was established for open flames and cutting and welding operations. The Safety Office coordinated fire insurance carrier efforts in the areas of inspection of the campus, testing of water supply and pumps for sprinkers, and review of building plans.

Physical Facilities

This year there was a marked increase in large facility safety review by the Safety Office. Large facility review included the Arts & Media Center, the Plasma Fusion Center, the EG&G Building, the Undergraduate Chemistry Laboratory, Brooks Center, the VLSI facility, W91, and E51 and E52. There was a considerable drop in the number of small renovations reviewed.

Safety Audits

Safety audits were performed for Chemical Engineering, Lincoln Laboratory, Endicott House, and Lincoln Laboratory field stations.

A complete fire prevention survey of the main campus was completed by our insurance carrier, Kemper Insurance, in cooperation with our office.

Off Campus Sites

Significant at Lincoln Laboratory was the transferring of the Safety program from Division I to the Director's Office and the forming of a new Safety Committee.

All remote Lincoln field sites were visited by Safety Officer personnel. They included Alberta, Canada; Kwajalein, Marshall Islands; Maui, Hawaii; San Juan Capestrano, California; and Geors and Hel sites at White Sands Missile Range in New Mexico.

Industrial Accidents

Lincoln Laboratory Safety Office is now responsible for the administration of workers' compensation cases. Educational and administrative programs were initiated and are continuing to implement this change.

JOHN M. FRESINA

Vice President, Research

Francis Bitter National Magnet Laboratory

The Francis Bitter National Magnet Laboratory, with support from the National Science Foundation, operates a high magnetic field facility available to research scientists from throughout the country and the world. The Laboratory's research staff also conducts basic and applied research in condensed matter physics, condensed matter chemistry and biophysics.

This past year, the new 30 tesla, 33 mm bore, hybrid (superconducting and water-cooled) magnet system has been integrated into the regular magnet facility operations and has been used for several important experiments where the highest possible continuous fields were required.

One of these experiments, an investigation of the quantized Hall effect in two-dimensional electron gases, was one of the most significant experiments in condensed matter physics in this past year. The study of an electron gas which is constrained to be two-dimensional is at the forefront of materials research since very unusual physical properties have been predicted for such systems. An electron gas that is very nearly two dimensional is found within the inversion layer near the surface of a semiconductor at very low temperatures. Two years ago, scientists in West Germany observed that the transverse resistance (Hall resistance) of such an electron gas took on step-like values as a function of an external magnetic field. Furthermore, the values of the resistances of the steps were independent of material properties and could be indexed by integers; it has therefore been named the Quantized Hall Effect. The flatness of the steps and the precision of the resistance values were quite unexpected and represent a most important discovery. D. Tsui, formerly at Bell Laboratories and now at Princeton University and his colleagues, H. Störmer and A. Gossard of Bell Laboratories, have extended these studies to very high magnetic fields (above 20 tesla) and very low temperature by using the facilities at the Laboratory. They not only confirmed previous results, but also found non-integral values (1/3, 2/3, 2/5, 2/7, 4/5, etc.) all with odd denominators. Theorists have shown that these results are consistent with the properties of a charged quantum fluid of a previously unknown type.

Brief summaries of the activities of the research staff are given below.

SUPERCONDUCTIVITY

Recent advances in superconductivity include the following experiments:

1) Powder processed NbAl multifilimentary wires were fabricated with improved overall critical current densities of 10^4 A/cm^2 at 20 tesla at 2K.

2) Powder processed Cu-Nb-Sn materials were fabricated by hydrostatic extrusion followed by wire drawing to achieve 10^4 A/cm^2 at 16 tesla for relatively low areal reductions, demonstrating improved processing.

3) Systematic effects of oxygen in the superconducting properties of rare earth molybdenum sulfides were observed. The sensitivity to oxygen suggests an explanation for reports which showed variable results for pressure induced superconductivity in $EuMo_6S_8$.

4) An image effect in superconducting magnets, which results from the distortion of the flux in a sample because of the shielding effects of the superconductor was examined in detail. The effect is strongly dependent on geometrical effects, can produce a substantial error in magnetic measurements for unfavorable geometries, is field dependent and can be minimized based on this analysis.

Research in Thin Film Superconductivity

Tunneling characteristics of ferromagnetic-insulator-aluminum tunnel junctions have been used to determine the splitting of the quasiparticle states in Al near the normal-superconducting phase boundary. This measurement gives a value of the antisymmetric Fermi liquid parameter in aluminum. An electron-gun source for deposition of vanadium and the use of nitrided amorphous silicon barriers have led to reliable production of tunnel junctions on very thin films of vanadium nitride. The dual-electron-beam evaporator has produced high quality films of Nb and VTi. Films of NbN and V_3Ga with superconducting transition temperatures of 14K have also been deposited.

LOW TEMPERATURE PHYSICS AND MAGNETISM

Seven groups have used the ^{3}He cryostat in the past nine months. Their experiments involved magneto-transport measurements on a variety of semiconducting structures and materials and also on graphite. Four of the investigations used the 30T hybrid magnet. The ^{3}He dilution refrigeration facility has been operating down to 50 mK and at fields to 15 teslas on a regular basis. Fifteen experimental runs with 12 different research groups were completed. The research was mainly in low dimensional electronic systems, including the quantized Hall effect and organometallic linear chain conductors.

SEMICONDUCTORS

In semimagnetic semiconductors, we have measured exchange energies by spin-flip Raman scattering and magneto-reflection; produced magnetically tunable stimulated emission via recombination of electrons and holes; studied the magnetic field tuning of the band gap through photoluminescence; and used nonlinear wave mixing to study electric dipole spin resonance.

The magnetic field dependence of the energy levels of two-dimensional electron and exciton gases in GaAs-GaAlAs quantum wells was studied via photoluminescence spectroscopy. A new technique for measuring magneto-absorption spectra by observing recombination radiation was also demonstrated in GaAs.

Experimental and theoretical work on quantum well structures has produced some unique results. Study of luminescence of a single quantum well has exhibited extraordinary nonlinear behavior attributed to thermodynamic transport of excitons. The magnetoluminescence contains a rich Zeeman spectrum. Theoretical treatment of a periodic heterostructure laser has been formulated. An experimental program on a cyclotron resonance enhanced free electron laser, in collaboration with Professor Bekefi (Physics), is making satisfactory progress.

The effect of electron-phonon interaction on the energy levels of dilute electron lattices is being investigated. It has been shown that coherence effects occur when the wave vector of a virtual emitted phonon matches a reciprocal lattice vector of the electron lattice, producing, over all, an increased electron-phonon interaction compared to the isolated electron case.

High precision measurements of complex refractive index and complex dielectric permittivity were made on a variety of millimeter wave materials such as silicon, GaAs, alumina, sapphire, fused silica and dimethyl siloxane coolant liquids. Magnetic field dependence of the spin splitting of $1s \rightarrow 2p$ ($m = +1$) donor transition in GaAs has been observed. The hydrogen-like $1s \rightarrow 2p$ ($m = -1, 0, +1$) transitions of two donors have been observed in high intensity magnetic fields up to 8.5 T for the ternary semiconductor, InGaAs. New line shapes, not predicted by Stark broadening, were observed for $1s \rightarrow 2p$ ($m = -1, 0$) for a single hydrogen like donor in InP.

LIQUID CRYSTALS

Work was centered primarily on high field investigations of liquid crystal phase transitions. The contention by Keyes that the nematic-isotropic phase transition is tricritical in nature was proved faulty; evidence was found that the transition is actually classical. Very recently, it has been shown here in conjunction with S. Kumar and J.D. Litster (Physics) that the lyotropic liquid crystal caesium perfluoro-octanoate + water can be cooled in the isotropic phase to within 50 mK of the supercooling limit; thus, the first truly critical measurements of the nematic-isotropic transition are being made. In addition, the interface between a nematic liquid crystal and surfactant-treated glass surface has been investigated and characterized in a joint study with R.H. Yong of IBM. This project may have important technological implications. Work on hexatic phases has also continued, in conjunction with J.T. Ho (SUNY, Buffalo), and it has been shown that the smectic A to hexatic-like smectic F phase is dominated by the tilt component of the order parameter. Finally, work is beginning on more biologically relevant macromolecular systems. Preliminary investigations have already been made on the alignment and polymerization of both collagen and fibrinogen in high magnetic fields.

MAGNETISM IN LIVING SYSTEMS

The process by which magnetotatic bacteria produce particles of Fe_3O_4 has been studied. Iron is transported into the cell and concentrated in the form of hydrous-ferric-oxide. Reduction of this material leads to precipitation of Fe_3O_4. $FeCl_3$-doped polyacetylene is a conducting polymer. Study of this material as a function of dopant concentration shows that some of the iron atoms are reduced to Fe^{2+}. At a concentration of about 1 mole percent, the Fe^{2+} ions form aggregates of $FeCl_2 \cdot 2H_2O$. Aggregate formation appears to coincide with a semiconducting to metallic transition in the conductivity.

The Low Field Group has completed several studies and prepared a number of publications concerning the use of magnetoencephalograms as a tool for retrieving information about electrical sources in the human brain.

NUCLEAR MAGNETIC RESONANCE

1) Protein-DNA Interactions

The physical basis of protein-DNA recognition is being intensively investigated using 500 MHz proton nuclear magnetic resonance (NMR). Three projects by groups from MIT, Harvard and the University of Pennsylvania are underway which are examining the cro-, lac-, and lambda cI repressors from bacteriophage λ and the complexes which they form with their respective DNA operators. Besides the use of two-dimensional NMR and special data processing techniques, a battery of biochemical techniques such as genetic manipulation, cloning, proteolysis and deuterium and fluorine labelling have been employed. Binding sites on the protein and DNA can be studied at the level of a single proton resonance from an amino acid or nucleic acid. Information on the conformation and dynamics of the repressor alone, of the operator alone and of the two together in the repressor-operator complex is being obtained. The structure of the protein-DNA complex and how the proteins recognize specific DNA sequences from the other 10^6 base pairs in the cell is a very general question of central importance in molecular biology and pertains ultimately to the cancer problem.

2) Membranes

Phase transitions and equilibria have been studied in a number of pure and mixed lipid systems with ^{13}C and ^{2}H NMR.

3) Proteins

Side chain dynamics in bacteriorhodopsin (bR) have been examined with ^{2}H NMR. In addition, magic angle sample spinning (MASS) has been used to study ^{13}C retinal labeled bR, ^{15}N Schiff base labeled bR, and ^{15}N His labeled α-lytic protease. In each of these cases an attempt is being made to understand how the proteins function.

4) NMR Methodology

The general goal in this research area is to develop new NMR experiments which enable the spectroscopist to do spectroscopy better. Recently, two dimensional MASS experiments have been developed which separate chemical shift and dipolar interactions and isotropic and anisotropic chemical shifts into two orthogonal frequency dimensions.

MAGNET TECHNOLOGY

1) Hybrid Magnets

The 30 tesla, 33 mm bore hybrid magnet has been integrated with regular magnet operations as operating personnel have mastered its complexity. With the acquisition of spares for both the 1z and 2z inserts, operating time has been increased. Steps to improve helium management have also been instituted.

We are progressing along the road toward a 32 T hybrid with the construction of a second Nijmegen system. An 11 T superconducting magnet, utilizing niobium-titanium at temperatures of 1.8 K, is being built. The alternative of a conductor based upon niobium-tin is being evaluated for the next MIT hybrid system.

2) Water-cooled Magnets

Our highest-field water-cooled systems are demonstrating excellent longevity, with two magnets of each of two types generating fields as high or higher than ever before: 22.6 T in 33 mm and 20.0 T in 54 mm.

3) 14 T NMR Program

The design of the magnet system has been completed and niobium-tin and niobium-titanium wire ordered. Joints in niobium-tin wire have been successfully made.

4) Pulsed Coils

The use of the Alcator power supply to drive a pulsed coil has been shown by a computer code to lead to a field of only 45 T with currently available copper-steel composites. New high-strength copper-base composites may allow substantially higher fields. The design of short pulse magnets energized by a capacitor bank has indicated that up to 90 T could be generated by a 1 Megajoule bank and a program of design and construction of coils leading to about 90 T has been started.

5) Pulsed Field Facility

A pulsed field facility, operating in a user mode, is being initiated for fields up to 45 tesla using nitrogen-cooled multilayer Cu coils supported in a hardened steel structure. Initially, pulsed fields to 45 teslas with a half-period 10 msec will be furnished to users.

APPLIED MAGNETISM

1) Magnetic Separation

The DOE-funded pilot plant study of high gradient magnetic separation (HGMS) applied to coal cleaning is nearly completed. NSF has renewed the grants for fundamental HGMS and selective mineral component separation studies. The coal cleaning pilot plant should be installed in the Electric Power Research Institute's test facility in the fall and a new high field project on submicron particle capture has been proposed to NSF.

2) Electromagnetic Acceleration

Construction and initial testing of the triggered vacuum arc switch supported by NASA has been completed. Magnetic augmentation is now under development. Accelerator technology studies supported by the Army are progressing on several fronts. A rail gun instrumentation test bed has been designed and is under construction. Dynamic studies of thin build pulse coils have produced many insights. The switching control problems of the multi-stage induction accelerator have been solved and two stage operation is commencing.

PETER A. WOLFF

Center for Materials Science and Engineering

The Center for Materials Science and Engineering (CMSE) was founded in 1960 for the study of the structure and properties of materials. Major funding for the Center programs is provided by the National Science Foundation (NSF) under the Materials Research Laboratory (MRL) program. The Center operates central facility laboratories which provide state of the art instrumentation and the expertise of professional staff to foster research projects and enhance funding opportunities by the materials community at MIT. Major facilities added this past year include a molecular beam epitaxy system. The first such machine on campus, it will enable the growth of layered materials with control of composition on a scale approaching 10^{-9} meter. Another major addition was an electron microanalyzer; by analyzing the characteristic X-rays that result from electron bombardment it enables chemical analysis of material composition with a spatial resolution of 10^{-8} meter. Other additions include new scanning and transmission electron microscopes and a nitrogen-oxygen determinator for our chemical analytical facility.

The Center also funded 35 research projects carried out by 31 faculty from the Departments of Chemical Engineering, Chemistry, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Physics. This is collaborative interdisciplinary research of a type difficult to fund through direct grants from funding agencies to a single investigator, and is organized into several areas of thrust.

As an important part of our research program, the Center provided seed funding of programs to 12 investigators during the past year. This funding provides an opportunity for junior faculty or new senior faculty to develop strong programs which can either be incorporated into one of our areas of thrust or receive continuing support from other sources.

A weekly colloquium series covering a range of topics as broad as the interests of members of the Center was conducted, along with support of weekly seminar series on polymer research as well as one devoted to condensed matter physics. The central facilities laboratories offered several program training courses during IAP which provided hands-on training for students and staff.

Below we outline briefly the activity of the research thrust areas during the past year, which was the first of a new three-year grant from the NSF. The names and departmental affiliations of the individual researchers are given; there have been some changes in personnel and direction since last year.

Research on Flow and Fracture in High Temperature Alloys

This group has carried out a number of related studies of refractory alloys. Creep and fatigue crack initiation and growth are investigated both empirically and fundamentally; various materials are prepared and subjected to environmental stresses, then examined using the electron microscopy facilities of the Center. Theoretical modelling is both phenomenological and microscopic; the latter based on the interactions of dislocations at grain boundaries and with precipitate dispersions.

During the past year an induction heating apparatus has been developed to allow thermal shock testing of specimens under conditions simulating the corrosive environment encountered in marine gas turbines. This will also be important for development of materials for turbines designed to run on low grade fuel. New testing facilities and theoretical models have also been developed to study oxide dispersed alloys whose high ductility offers promise of thermal shock resistance.

Faculty/Department: Professors Robert Balluffi, Nicholas Grant, Regis Pelloux, Samuel Allen (Materials Science and Engineering); and Ali Argon, Frank McClintock (Mechanical Engineering).

Structure and Properties of Microcrystalline and Glassy Alloys Produced by Rapid Solidification

Amorphous and microcrystalline metals produced by rapid cooling continue to gain in technological and economic importance. This thrust area has the goal to produce new varieties of these materials, to study their properties, and to acquire the basic understanding needed for materials design. This understanding has progressed to the point that it is possible to predict which materials will have superplastic behavior, and the predictions were verified in aluminum alloys as well as microduplex stainless steels (ferrite plus austenite) that were produced this past year. Quantitative prediction of the superplastic deformability remains elusive.

Work is under way to extend studies of the effect of grain size on strength and ductility, which has been carried out for grain sizes from 1000 microns to one micron, to grains as small as 0.01 micron. Materials will be characterized by electron microscopy and models for dislocation kinetics are being developed.

On a very fundamental level, quantum mechanical calculations to predict the electronic structure and glass forming capability of amorphous alloys continues. These materials often have excellent corrosion resistance, and these properties are being studied.

Faculty/Department: Professors Nicholas Grant, Keith Johnson, Ronald Latanision, John Vander Sande (all Materials Science and Engineering).

Catalytic Activity and Surface Structure

The focus of the basic research programs in this thrust area is the effect of local surface environment on electronic structure and catalytic activity. These effects are studied experimentally and theoretically by modification of the catalyst-support interactions on electrode surfaces and by modification of the surface structure on single crystal transition metal surfaces.

Chemical modification of electrode surfaces to provide catalytic routes for electron transfer reactions is being studied. Specifically, this includes the modification of impregnated polymers confined to electrode surfaces so as to attain both long-term durability of the polymers and useful electrochemical rates of such technologically important reactions as the reduction of CO_2 by H_2. Theoretical work by self-consistent molecular orbital calculations of palladium impregnated polymer catalysts attached to electrode surfaces as well as the electrolyte interactions is proceeding.

The effects of surface structure on the first step of a surface chemical reaction, that of adsorption, are under investigation. By varying the energy of the incident molecule, the dynamics of the adsorption process is probed, thereby providing insight into how the interaction potential between the adsorbing species and the surface is modified by the presence of structure such as steps on the surface. Systems under investigation include the dissociative adsorptions of CO_2 and CO on Ni and Pd, gas phase analogs of the reduction reactions under investigation in an electrochemical environment. These adsorption mechanisms are studied theoretically by calculating their energy transfer rates with methods which range from the solution of the classical equations of motion via the generalized Langevin equation to the solution of the quantum mechanical time dependent Hartree equations for the surface-molecule system. The interaction potential modeled, and hence the adsorption and scattering process, will be refined by the experimental information obtained.

Faculty/Department: Professors Keith Johnson (Materials Science and Engineering); Sylvia Ceyer, Robert Silbey, Mark Wrighton (Chemistry).

Defects in Solids

The focus of this thrust area has continued to sharpen with further changes in personnel and in research direction. The common theme is now the study of defects in electronic and opto-electronic materials, and the area is closely linked by a common application of microelectronics processing technology to both investigate and to exploit these materials. Fruitful collaborative efforts are active in research on understanding the electronic properties of amorphous silicon and chalcogenide glasses, and on the nature and role of defects in silicon and III-V crystalline semiconductors. The expansion of the facilities of the Microelectronics Laboratory and upgrading of the Ion Implantation Facility have had a major positive impact on this area; and continued growth in the semiconductor technology and device area is expected as part of a rapidly growing research effort in Very Large Scale Integration (VLSI) at MIT.

In the past year, field effect transistor based time-of-flight measurements have yielded new data on dispersive transport in low-gap amorphous materials. These results and recent photoluminescence observations have coupled well to the expanded theoretical effort on the modeling of defects in amorphous materials. Progress on low temperature deposition of amorphous and polycrystalline silicon films has also been significant and has yielded new insight into the role of the plasma energy in this process.

In work that promises wide technological impact, an ultra-high intensity arc lamp has been applied to anneal ion implanted gallium arsenide and indium phosphide with dramatic success. This effort will expand in the next year both within the III-V program as well as to the silicon process modeling work. Important progress has recently been made in the later effort in understanding the role of self-interstitials in dopant diffusion. Finally, a unique deep level transient spectroscopy system utilizing linear predictive modeling has been perfected and demonstrated on defect levels in gallium arsenide devices.

Faculty/Department: Professors David Adler, Dimitri Antoniadis, Clifton Fonstad, Rafael Reif, Stephen Senturia (Electrical Engineering and Computer Science); John Joannopoulos, Marc Kastner, Patrick Lee (Physics); and Harry Tuller (Materials Science and Engineering).

Phase Transitions

The continuing goal of this thrust area is to understand the many phases that occur in condensed matter as fundamentally as possible. The theoretical approach is to use phenomenological models where necessary but

to solve the statistical mechanics of the many body Hamiltonian, using the most modern computational techniques, wherever possible. Experimentally, behavior is probed using quasielastic light scattering, high resolution X-ray scattering, neutron scattering, and precision calorimetry.

A significant effort is currently devoted to studying the phases of smectic liquid crystals and research this year has confirmed that the density wave of smectic A materials has two different correlation lengths for short range order. This is a result different from any other known phase transition and at variance with current statistical mechanical theories.

Light scattering is used to study the structure of complex liquid phases including polymer solutions, gels, and micellar phases. During the past year it has been possible to observe and study the coil to globule transition of single polymer chains. The results can be quantitatively described by conventional theories of critical behavior modified by the finite size of the polymer molecule.

Faculty/Department: Professors Carl Garland (Chemistry); and Robert Birgeneau, David Litster, Thomas Greytak, George Benedek, Ahmet Berker, Toyoichi Tanaka (Physics).

Deformation and Fracture in Polymer Composites

The goal of this thrust area is to understand the micro-structural causes and mechanisms of toughness in polymer composites. There has been increased emphasis on the production of perfect graphite fibers, modified by intercalation, for reinforcing polymer composites.

There has been considerable progress this year studying dilational (craze) plasticity of polystyrene. The addition of both polybutadiene block copolymers and higher molecular weight polystyrene composite particles have been found to modify the properties favorably. Theoretical models have been developed which can give quantitative agreement with the experimental results. Benzene-derived precursor graphite fibers have been studied by the wide variety of analysis techniques - lattice fringing measurements, electrical conductivity, magneto resistance, Raman scattering, and X-ray diffraction - available in the Center. The carrier mobilities were comparable to those of highly oriented pyrolytic graphite, indicating a high degree of perfection in the fibers.

Faculty/Department: Professors Ali Argon (Mechanical Engineering); Robert Cohen (Chemical Engineering); Mildred Dresselhaus (Electrical Engineering and Computer Science); and Donald Uhlmann (Materials Science and Engineering).

X-Ray Scattering with Synchrotron Radiation

This is a collaborative effort with researchers at IBM to instrument a beam port with two spectrometers on the X-ray ring at the National Synchrotron Light Source at Brookhaven National Laboratory. The intense radiation will enable measurements not possible to carry out using conventional laboratory sources. The construction of our two spectrometers is essentially complete and awaits the operation of the storage ring. While waiting for the Brookhaven facility to come on line, we have begun in-house studies of freely suspended liquid crystal films and have discovered some interacting structural phase changes in the smectic B phase by using the storage ring at DESY in Hamburg. Other experiments have been carried out at the Stanford Synchrotron Radiation Laboratory, resulting in the discovery that a two dimensional incommensurate solid (of Krypton on graphite surfaces) first melts to a liquid phase, then freezes to a commensurate solid on cooling, and finally undergoes re-entrant melting to a liquid again upon further cooling.

Faculty/Department: Professors Robert Birgeneau, David Litster (Physics).

J. DAVID LITSTER

Energy Laboratory

The main purpose of the Energy Laboratory is to encourage mission-oriented research on a broad range of energy problems through the interactive participation of people drawn from most of MIT's academic departments. The greatest single research emphasis is the efficient, economic, and socially responsible use of the increasingly "dirty" fuels of the future such as coal, tars, heavy crudes, and shale. Specific projects focus on combustion in furnaces and engines, health effects of emissions, energy supply and demand, and conversion to clean fuels. In addition to that work, Laboratory programs include research on conservation, renewable energy sources, nuclear energy, and conventional oil and gas in both technological and economic/policy projects.

Operating expenses of the Energy Laboratory during fiscal year 1983 were about $9.3 million--a decrease of almost 25 percent in real dollars from last year. There was, of course, a corresponding decrease in personnel, with the burden falling more heavily on staff than on faculty and students participating in Laboratory research projects. Most of the reduction in expenditures was due to cuts in funding from the US Department of Energy. We believe that the largest cuts have now taken place and that overall funding will be reasonably stable through fiscal 1984.

We made several internal organizational changes during the past year. In spring 1983 a new Steering Committee was appointed, whose purpose is to review Laboratory activities once a year to be sure they are consistent with the interests of MIT's schools and administration, and to offer suggestions for improvement. Members of the new committee are: Dr. Kenneth A. Smith, associate provost and vice president for research, chairman; Dr. Francis E. Low, provost; Dr. John M. Deutch, dean of the School of Science; Dr. Harold J. Hanham, dean of the School of Humanities; Dr. Abraham J. Siegel, dean of the Sloan School of Management; and Dr. Gerald L. Wilson, dean of the School of Engineering.

David O. Wood has been appointed an associate director of the Energy Laboratory, a position he held prior to devoting his major efforts to heading our research program on "Studies in Energy and the American Economy." He will be responsible for work on energy management and economics, replacing Professor Henry D. Jacoby, who goes on sabbatical in the coming year.

The Center for Energy Policy Research (CEPR) now has 37 associates--organizations from the private and nongovernmental public sectors that provide financial support and participate in CEPR's energy policy research and analysis. During the year, the CEPR held a major symposium on the US electric power industry and an international meeting called "The Future of Natural Gas." A change in the CEPR's operating procedure took place when the Energy Laboratory's Management Committee established a CEPR Program Board. The purpose of the board is to assist the CEPR in developing an expanded portfolio of research and analysis projects, and to integrate those projects with a broader range of work going on elsewhere at MIT. Members of the board for the coming year are David O. Wood of the Energy Laboratory and the Sloan School of Management (chairman), Professors Paul L. Joskow and Daniel McFadden of the Department of Economics, Professor Stewart C. Myers of the Sloan School of Management, and Loren C. Cox, director of the CEPR.

A major addition to our research program came with the transfer of the Northeast Residential Experiment Station project from Lincoln Laboratory to the Energy Laboratory. Initiated in 1980, this DOE-sponsored project investigates the performance of grid-connected, residential-scale solar photovoltaic (PV) energy systems appropriate for applications in northern climates. Almost 200 people toured the Experiment Station as part of the first national conference on PV applications, held at MIT in late March. Sponsored by the Energy Laboratory and the New England Solar Energy Association, the conference--called "Photovoltaics: From Research to Reality"--attracted almost 500 people with an interest in designing and marketing PV systems.

Specific research accomplishments during the year covered a large and diverse set of topics. Some of the topics of more general interest were summarized in our quarterly research bulletin, e-lab, under the following headings, grouped here in three categories:

Management, Economics, and Policy
- --Deregulating the electric utilities
- --Natural gas pipeline regulation after field price decontrol
- --Factors affecting the adoption of cogeneration
- --Forecasting cogeneration growth and its effect on electric utilities
- --Energy demand and policy in Mexico
- --Responding to interruptions in oil supply

Environment, Health, and Safety
- --Strategies for controlling acid rain
- --Ponding of effluents from fossil-fuel power plants
- --Polycylic aromatic hydrocarbon production in a jet-stirred reactor
- --Hydrocarbon formation in direct-injection spark-ignition engines
- --Failure detection in complex physical systems

Other technical research
- --Rapid solidification of ceramics
- --Beneficiation of oil shale
- --Chemical reactions in flames
- --Evaluation of grid-connected residential photovoltaic systems
- --Oil-free pistons for engines

Information on all the projects being performed in the Laboratory may be obtained from Project Summaries, July 1, 1982 - June 30, 1983. The following material describes the major thrusts of the Energy Laboratory's principal research areas.

RESEARCH AREAS

The Energy Laboratory's International Energy Studies Program conducts research on economic, political, and strategic aspects of international energy trade (oil, nuclear fuels, and other energy commodities) and on the financial implications of the large reciprocal flows of wealth associated with that trade. New directions for research include couplings between domestic US and foreign markets, security of supply concerns and their effect on national policies and international relations, the roles of public and private sectors in dealing with supply crises, and the energy problems of the developing world. (Dr. Thomas L. Neff, program director)

In the Utility Systems Program, faculty and staff from MIT's engineering and policy science departments analyze utility operations and growth, both short run and long run. Their research focuses on four areas: electric utility operations and control; economics and policy decisions associated with adoption of new energy technologies; development of modeling tools for utility operation and utility capacity expansion analysis; and economics of regulation/deregulation of the electric power system. (Professor Fred C. Schweppe, program director; Dr. Richard D. Tabors, program manager)

The Energy Markets, Pricing, and Regulation Program conducts research on the structure and performance of the domestic system for the supply, conversion, and use of energy. Current projects include research on macroeconomic consequences of energy supply shocks and price uncertainty; the wealth and income distribution effects of changing energy supply and price conditions; the structure and regulation of the US electric utility industry; and the relation between energy prices and availability, and capital formation and replacement. (David O. Wood, program director)

The Energy Systems Assessment Program studies options for future energy systems by evaluating the short- and long-term impact of energy systems and by identifying R&D needs and initiating projects to solve the identified problems. International cooperative activities are planned for this program. The integration of distributed photovoltaic systems into a power grid is also under study. (Professor Thomas H. Lee, program director)

The Combustion Research Facilities Program emphasizes parallel modeling and experimental investigations of combustion of gaseous, liquid, and solid fuels in both steady and unsteady operation. A special feature of the experimental studies is that detailed flame data are obtained in large-scale pilot plant combustors in which the combustion-heat transfer processes closely simulate industrial practice. (Professor Janos M. Beér, scientific director; Dr. Malcolm T. Jacques, combustion engineering manager)

Research in the High-Temperature Reactions and Health Effects Program concentrates on the oxidation and pyrolysis of fuels and on techniques for controlling emissions from those processes. Of particular interest are coal char gasification and rich mixture combustion, which involve problems of catalysis, capture of sulfur, and reduction of particulates and nitrogen oxides. Studies of the formation of mutagens in hydrocarbon combustion involve a team effort among engineering, analytical chemistry, and biological sciences. (Professor John P. Longwell, program director; Dr. William A. Peters, program manager)

The Transportation Propulsion Program is based on the activities of the Sloan Automotive Laboratory. The work includes fundamental combustion studies, internal combustion engine research, gas turbine and burner research, and policy and technology studies. (Professor John B. Heywood, program director; Dr. Jack A. Ekchian, program manager)

The Advanced Energy Materials Program examines new and emerging technologies in such areas as electrodes and electrolytes for high density batteries and fuel cells, synthesis of ceramic powders using laser heat sources, rapid solidification of molten ceramics, solar heating/cooling, amorphous photovoltaics, and broad band antireflective coatings. (Dr. John S. Haggerty, program director)

Research in the Environmental Program seeks to identify and reduce the environmental impacts of energy-related facilities and includes a diverse range of research projects. Current projects consider cooling systems for electric power plants, water management issues associated with coal development, impacts of acid rain, local effects of air emissions, and environmental implications of ocean thermal energy conversion. (Professor Jay A. Fay, program director; Dr. E. Eric Adams, program manager)

The Nuclear Program has the following broad objectives: to provide direct technical contributions to nuclear plant reliability and safety; to investigate possible improvements in nuclear plant design for more efficient utilization of nuclear fuel resources; and to develop and communicate information that will contribute to public understanding of nuclear power. (Professor Norman C. Rasmussen, program director; Dr. William D. Hinkle, program manager)

The Energy-Efficient Buildings and Systems Program examines the behavior of existing buildings and components and seeks to develop new technologies with better energy efficiency. Current projects include studies of the transfer and accumulation of moisture in structures retrofitted with insulation, heat loss from building foundations, and the insulating value and aging characteristics of closed-cell foam insulation. (Dr. Leon R. Glicksman, program director)

The Center for Energy Policy Research focuses on policy research and analysis and on making results available and useful to policy makers. With support from its Associates, a wide range of US and international corporate and noncorporate interest groups, the Center holds conferences and seminars to bring together key government and private organizations to work on energy-related policy issues. The work of the Center is done by professional staff members from the Energy Laboratory, faculty and students from several MIT departments (particularly the Sloan School of Management and the Department of Economics), and specialists from the Center's Associates. (Loren C. Cox, director)

The Synthetic Fuels Center focuses on research on conversion of coal, oil shale, and other energy resources to liquid and gaseous fuels. (Dr. Malcolm A. Weiss, director)

The Electric Utility Program serves to inform participating companies about ongoing MIT research activities, to identify and discuss utility needs and priorities, and to develop research projects responsive to those needs. The member companies currently participating in the program include 8 utilities and 9 other companies involved in supplying fuel, equipment, or services to the industry. (Dr. William D. Hinkle, director)

PUBLICATIONS

During the past year, Energy Laboratory research resulted in 42 technical reports, 37 working papers, and about 110 other publications (journal articles, workshop and conference presentations, etc.). Energy Laboratory Headquarters has available a list of reports and working papers published since 1977 as well as copies of Project Summaries and e-lab.

NANCY W. STAUFFER

Nuclear Reactor Laboratory

During the past year the Nuclear Reactor Laboratory (NRL) engaged in joint activities with seven academic departments and several interdepartmental laboratories, the Charles Stark Draper Laboratory, and 27 other universities and nonprofit research institutions, such as teaching hospitals. The spectrum of these joint research or teaching and training activities includes neutron scattering studies of condensed matter, nuclear materials research and development, radiochemistry and trace analysis applied to health effects of coal use, nutrition studies, earth and planetary sciences, nuclear medicine, reactor engineering, computer control of reactors, and training in reactor operations.

Professors Clifford G. Shull and Anton Zeilinger and their group have continued studies of neutron diffraction by crystals, of neutron interferometric systems, and of fundamental neutron properties. In passage through extended, perfect crystals neutrons are expected to display an effective mass which is far smaller than the normal mass (by five orders of magnitude) according to dynamical diffraction theory. Experiments have been performed which give a direct demonstration of this dramatic effect by applying a transverse force to the neutron beam through the agency of a magnetic field gradient. Not only is an anomalously large acceleration observed but, as well, both positive and negative values for the effective mass are encountered. Interferometer studies have continued with tests on the nature of coherence within the system and with the preparation of a new type of Bragg reflection interferometer. The latter, because of its unique geometrical features, has the potential for development of a new phase topography technique in scanning specimens. Further studies have been carried out on the identification of thermal diffuse scattering and Huang defect scattering occurring simultaneously with Bragg diffraction. Theoretical investigations have continued on the neutron phase effect in moving refractive media, on delayed-choice aspects of neutron interferometer experiments, on spin-orbit scattering effects and their relation to a Pendellosung-spin resonance phenomenon, and on neutron wave packet considerations. A total of four students and four senior collaborators participated in the group's research activities. One Ph.D. and one S.M. thesis were completed.

Dr. Charles V. Berney continued his neutron-scattering studies of polymer structure, carried out in collaboration with Professor Robert E. Cohen of the Department of Chemical Engineering. Phase-separated diblock copolymers of spherical morphology were studied, and information about domain size, domain packing, and domain boundary thickness was obtained. Values of the latter parameters were in agreement with current theory, but domain size was found to increase much more slowly with molecular weight than calculations had predicted. This work resulted in an Sc.D. thesis, and is being reported in Polymer and Macromolecules.

Medical applications under Professor Gordon L. Brownell have continued in the areas of boron neutron capture therapy (BNCT) and positron tomography. In the first area, the study of BNCT therapy on beagle puppies with brain tumors has been concluded. Manzar Ashtari carried out much of the physical studies of radiation dosimetry as part of her doctoral thesis. John Kirsch is continuing the study on the development of track etch autoradiography to determine the distribution of boron-containing compounds in tissue. The aim of these studies is to determine the ultimate resolution of this imaging technique.

Medical imaging using reactor produced isotopes is assuming increased importance in biomedical research. Studies on F-18 production at the MIT reactor have indicated that this isotope can be produced in adequate quantities. The isotope is of importance in the development of labeled radiopharmaceuticals for the PET program at the Massachusetts General Hospital. Course 22.55 Biological and Medical Applications of Ionizing Radiation (Professor Brownell) and Course 22.56 Principles of Medical Imaging (Professors Brownell and Lele) make use of the MITR-II. Eight students were enrolled in Course 22.56 in the 1983 spring semester.

Increased life science activity this year included successful production of useful amounts of F-18 tagged TBAF. Significant improvements in isotopic purity for the Os 191-Ir 191m generator were also achieved by Dr. Barry W. Wessels' group. Two students completed their master's dissertations in this research area.

Professor Otto K. Harling and Dr. Wessels initiated a new master's subspecialty in Health Radiation Physics. This program in the Nuclear Engineering Department is designed to educate students to a high level of proficiency in radiation management and control. An important part of the curriculum involves use of the MITR-II, the Bates accelerator, and various other radiation related facilities in the Boston area to provide realistic laboratory experience for the students.

In Professor Alan C. Nelson's group the effects of mixed gamma and neutron radiations were studied on mammalian living red blood cells. In particular, they were looking for radiation induced cell membrane damage as viewed through the Scanning Electron Microscope (SEM) and, in addition, they examined cell membrane elasticity as a function of radiation dose. The radiation caused the cells to age prematurely and increased cell rigidity. The four stage disc-sphere damage transformation was characterized and the time-dependence of the stage populations was determined.

Professor Frederick A. Frey and his research group continue to rely on the MITR-II for neutron activation analysis of geologic samples. Within the last 18 months four students, who used the reactor extensively, received their Ph.D. degrees. Their research ranged from determining and understanding the distribution of platinum elements in the earth's mantle to

understanding the origin of midoceanic plate volcanism such as that forming the Hawaiian Islands, to understanding the volcanism that is associated with convergence of oceanic and continental plates such as along the western coasts of North and South America. The recently acquired computer-based activation analysis system utilizing four detectors has significantly improved data acquisition facilities and the laboratory is routinely utilized by five graduate students from the Department of Earth and Planetary Sciences, a postdoctoral fellow, a research staff scientist and Professor Frey. In addition, the laboratory is being used by earth-science researchers from the University of Massachusetts (Amherst), Middlebury College, and Vanderbilt University.

Dr. Morteza Janghorbani's radiochemistry group has continued to expand the breadth of their activities in the area of stable isotope applications in human studies. Recently they developed methodology for metabolic studies of MIT young adults in the areas of zinc, selenium, and copper nutrition. Much of the work is based on recently developed concepts of biologically labeled foods and has been carried out for the first time at MIT. In addition to their metabolic studies, carried out jointly with Professor Vernon R. Young of the Department of Nutrition and Food Science and the MIT Clinical Research Center, they have continued to develop collaborative programs in areas for which stable isotopic methods are the sole practical approach: studies with neonates, mineral metabolism in relation to human pregnancy, and many human metabolic disorders. They have ongoing programs with researchers at such other institutions as Purdue University (biological labeling of human foods), Wayne State University and the University of Michigan (zinc marginal deficiency in man; homeostasis of zinc-copper in Wilson's disease), and Yale University (mineral nutrition of neonates). This group has continued to provide key technical support for the coal combustion research of Professor Adel F. Sarofim in Chemical Engineering. Collaboration on research projects dealing with trace elements in relation to health continued with several other groups at MIT and with other institutions.

A major alloy development project for fusion reactor first wall materials was continued for the fifth year. This research is directed by Professor Nicholas J. Grant, of the Department of Materials Science and Engineering, and Professor Otto K. Harling, director of the NRL. Professor John B. Vander Sande, of the Department of Materials Science and Engineering, also participated in the project. Senior research staff included Drs. Janez Megusar, Douglas Imeson, and Marvin Lee. Two graduate students completed their Ph.D. dissertations and one his S.M., and several others are currently doing their research on this project. More than 40 journal articles and formal reports have been completed to date as a result of project activities. A major thrust of this research effort has been the exploration of the use of innovative alloy processing techniques, such as rapid solidification from the melt, for the purpose of developing primary first wall alloys for fusion reactor first wall applications. The development of improved first wall alloys is on the critical path toward economical fusion power. The MIT approach provides a means to manipulate alloy microstructure and microchemistry in order to beneficiate irradiation performance. Alloy design, alloy production, irradiation testing, and postirradiation characterization are the major parts of this interdisciplinary project. Important results from the program included a model for irradiation performance of Ti and C containing austenitic stainless steels and successful testing of highly irradiated (~40 dpa) miniature alloy specimens using a miniature tensile test developed at the NRL. Significant progress was also achieved in the development of a new miniature specimen test for the determination of the ductile-to-brittle transition temperature. Graduate students involved in all phases of alloy design, production, and testing obtained unique research experience in radioactive materials research.

Another active nuclear materials project has been an in-reactor irradiation experiment at the MITR-II. This experiment was designed to assess the performance of typical fusion reactor materials during operation as part of the fusion reactor first wall. In this sophisticated test, the metal alloys were subjected to stress and temperature cycles, ion bombardment, and fast neutron irradiation, all simultaneously. This work under the direction of Professor Harling was successfully completed by a Ph.D. student in the Nuclear Engineering Department. The final results indicate that, depending upon the stress state, surface ion bombardment can either increase or decrease service life. The range of appropriate variables was fully characterized and documented.

A new research project using the MITR-II for nuclear materials irradiations was initiated by Professor Harling and Dr. Gordon Kohse. This project is related to breeder reactor materials and will determine the effects of time, temperature, and fast neutron irradiation on the microstructure and mechanical properties of a prototypic breeder alloy which will be used in the low flux peripheral regions of breeder reactors.

The MIT reactor completed its 24th year of operation, its eighth since the 1974-75 shutdown for upgrading and overhaul. During the past year it continued its usual Monday through Friday operating schedule at the design power level of 5 MW, averaging 85 hours per week at full power, holidays included. Energy output for the MITR-II, as the upgraded reactor is now called, totaled 145,400 megawatt-hours at June 30, 1983. The MITR-I generated 250,445 MWH from 1958 to 1974..

The reactor was well utilized during the year, although still more experiments and irradiations can be accommodated due to the number and versatility of its many facilities. The reactor, as an integrated whole, was and continues to be used in a series of experiments designed to demonstrate the feasibility and advantages of reactor control by digital computer, as described further below. The neutron beam ports saw increased utilization for neutron diffraction experiments, as described earlier. The total number of material specimen irradiations was 3254, down from the highs of the two previous years but still in excess of preceding annual usage.

Development of radioisotopes for use in nuclear medicine, principally by researchers at hospitals and other universities, included: 1) production of Cl-38 for Drs. Bernard Hoop and D. C. Johnson, of the Pulmonary Unit in the Department of Medicine, Massachusetts General Hospital, who are studying the control of ventilation through the regulation of chloride ions in the cerebrospinal fluid in a dog model, 2) production of Au-198 seeds for cancer therapy for Dr. Philip

Cobb of the New England Deaconess Hospital, 3) research activities for Professor Webster S. S. Jee and Dr. Joseph Smith of the University of Utah Radiobiology Laboratory using solid state neutron track detectors to study the distribution of plutonium in animal models, and 4) production of Dy-165 for Dr. Michael R. Zalutsky of the Whitaker College of Health Sciences, Technology, and Management for research studies in the treatment of arthritis.

In a number of other areas, reactor irradiations and services were performed for research groups outside MIT: 1) the irradiation of sulfur targets for the production of 12 Curies per week of P-32 to label proteins for use in biological research was continued; 2) a Wellesley College UROP student, supervised by Professor Gene M. Simmons of the MIT Department of Earth and Planetary Sciences, used solid state nuclear track detection techniques to study the distribution of uranium and thorium in New England granite; and 3) under the direction of Professor Ann M. Hirsch of Wellesley College, one of their students used solid state nuclear track detection techniques to study the boron distribution in plants; 4) Professor Gene A. Clough of Bates College and one student irradiated apatite for fission track dating studies; 5) Professor Martin Posner of the University of Massachusetts at Boston and six graduate students enrolled in nuclear radiation physics and radiation biophysics performed nuclear experiment techniques on the reactor including reactor subcritical multiplication, reactor control rod worth measurements and neutron activation analysis; 6) Professor John Zotos of Northeastern University and one graduate student, using solid state nuclear track detectors, studied the uranium content of silicon; 7) research in geology using neutron activation analysis (NAA) for trace element determination was carried out by Professor Ray A. Coish of Middlebury College; 8) material specimens were irradiated for Dr. Edward Fireman of the Harvard-Smithsonian Center for Astrophysics for fission track dating of Antartic ice; 9) Professors J. Christopher Hepburn and Rudolph Hon and seven students of Boston College used NAA to determine trace elements in geological systems; 10) neutron activation analysis was used by an MIT graduate student to determine trace elements in oceanic systems for Woods Hole Oceanographic Institute; 11) irradiations were conducted for neutron activation analysis of filter and oceanic sediment by Dr. A. Fleer and two research assistants at the Woods Hole Oceanographic Institute; 12) research efforts aimed at demonstrating both the feasibility and the advantages of reactor control by digital computer were continued under the direction of staff members of the Charles Stark Draper Laboratory and Professor David D. Lanning, MIT Department of Nuclear Engineering. This program has demonstrated signal validation and fault detection techniques. Studies regarding reactor control have provided experimental verification of several control techniques that had previously been studied only theoretically. Work is now in progress to synthesize these techniques into a single robust control design.

New research facilities include: 1) a thermal neutron beam "chopper" for use by the Department of Physics junior laboratory and by Northeastern University under the reactor-sharing grant, and 2) an addition to the reactor core purge system for sampling radioactive gaseous effluents for the development of cadmium-telluride photo detectors.

The US Department of Energy (DOE) renewed its reactor- sharing grant whereby MIT is reimbursed for use of the reactor by other educational institutions needing such a facility for teaching or research purposes. DOE augmented the reactor fuel supply without charge to the institute and also continued its development program designed to demonstrate the feasibility of extending the lifetime of uranium aluminide fuels used in some of the nation's high performance reactors such as the MITR-II.

Finally, it is appropriate to note that the reactor in the coming year will celebrate the 25th anniversary of its initial criticality on July 21, 1958. In recognition of this event the Nuclear Reactor Laboratory is planning a special week in October. On October 17-19, 1983, it will host an International Symposium on the Use and Development of Low and Medium Flux Research Reactors, for which about 150 abstracts have been submitted. On the following two days, the Laboratory will sponsor the annual meeting of the National Organization of Test, Research and Training Reactors, to be attended by representatives from most such reactors at universities, US National Laboratories, and commercial facilities.

OTTO K. HARLING

Patent, Copyright and Licensing Office

Disclosures and Licensing

During the past fiscal year, 150 invention disclosures were received, 46 US patent applications were filed, and 50 US patents issued. Additionally, 118 patent applications were filed in foreign countries corresponding to 13 US applications. Gross royalty income from patent and copyright licensing totaled $1,641,378. In addition, industry committed approximately $836,574 in the form of research funding which is directly attributable to the licensing program, as this research support is in conjunction with option/license agreements to inventions. Licensing efforts during this past year have continued to be concentrated in the general area of medical/biological applications. Licensing and option agreements have been executed with industrial concerns in these areas as well as in the technologies related to energy-saving, metallurgical castings, and communications. This office continues to work closely with the Office of Sponsored Programs in negotiating industrial research agreements.

During this period, a considerable amount of time has been devoted to the review of an overall technology transfer program as implemented on behalf of the Institute through the Patent, Copyright and Licensing Office. In this respect, the entire operation has been reviewed by the Sponsored Research Visiting Committee and the Committee on Copyrights and Patents. As a result, two new staff positions within the Office have been authorized. One position will be devoted primarily to assisting the Office of Sponsored Programs in negotiating the intellectual property provisions of university/industrial research contracts, and the other position will be devoted to interacting with the Institute's Industrial Liaison Program in establishing and maintaining technology transfer contacts with the faculty as well as with member companies. Preparations are presently under way to prepare appropriate classifications/job descriptions and to initiate the interviewing of personnel to fill these positions.

ARTHUR A. SMITH, JR.

Plasma Fusion Center

During the past year there has been significant technical progress in Plasma Fusion Center (PFC) research programs. Outstanding technical excellence is the primary cornerstone of all PFC research activities, and a major emphasis is placed on providing the intellectual environment that fosters independent creativity both at the individual researcher level and on the scale of major fusion research facilities such as the Alcator C tokamak and the TARA tandem mirror. An important strength of the Plasma Fusion Center is the ability to evolve new ideas and concepts in critical physics and technology areas required for development of fusion energy, and to train students and professional researchers. The Plasma Fusion Center technical programs are principally supported by the Department of Energy's Office of Fusion Energy. During the past year, the funding level has been approximately $23 million. There are approximately 332 personnel associated with PFC research activities. These include: 25 faculty and senior academic staff, 66 graduate students, and 14 undergraduate students, with participating faculty and students from Aeronautics and Astronautics, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Physics; 115 research scientists and engineers, and 10 visiting scientists; 60 technical support personnel, and 42 administrative and support staff. At the present time, the Plasma Fusion Center's major experimental and engineering facilities are located at several sites on the MIT campus, including NW13 (Nuclear Engineering), NW14 (National Magnet Laboratory), NW16 (Plasma Fusion Center), Building 36 (Research Laboratory of Electronics), Building 38 (Electrical Engineering and Computer Science), NW20 (PFC Alternator), and NW21 (PFC Nabisco Laboratory).

ALCATOR CONFINEMENT EXPERIMENT

The Alcator experimental program continues to be one of the most successful and prominent tokamak confinement programs within the international fusion research community. The primary objective of the Alcator experimental program, headed by Professor Ronald Parker, is to develop the basic physics understanding of the stability, transport and radiation properties of high-temperature plasmas at near-reactor conditions and to develop radio-frequency methods for heating and driving currents in plasmas at thermonuclear temperatures. The main Alcator experimental areas include: device operations (Dr. David Gwinn); confinement studies (Dr. Steve Wolfe); plasmawall interactions (Dr. Earl Marmar); radio frequency heating (Professor Miklos Porkolab); and data acquisition and computations (Dr. Martin Greenwald). Design efforts on a follow-up device to the Alcator C experiment have been intensified during the past year by the toroidal systems development group (Drs. Peter Politzer and D. Bruce Montgomery). These efforts are now focused on a superconducting high-field tokamak, Alcator DCT, capable of a very long pulse or steady-state operation. Professors Ronald Parker and Bruno Coppi are overall Alcator program principal investigators.

Pellet Injection Studies: The confinement studies of plasmas under conditions of intense ohmic heating, the first phase of the Alcator C research program, have been extended by the use of pneumatically-injected pellets of frozen hydrogen. This fueling technique results in deposition profiles which are peaked much closer to the magnetic axis than is possible with the conventional gas-puffing procedure. The resulting adiabatic plasma response yields temperature profiles which are not in equilibrium with the pre-injection current density profile. The ensuing relaxation process of both the temperature and density radial profile provides useful information concerning the MHD stability of tokamak plasmas and also the particle diffusion coefficient.

In addition to basic information on plasma behavior, pellet injection has permitted tokamak operation at record plasma densities, nearly $2 \times 10^{21} m^{-3}$ near the magnetic axis. There is also preliminary evidence that energy confinement under conditions of pellet injection is improved over the conventional gas-puffing case. The combination of very high density n and improved energy confinement time τ_E should then result in advancement of the Lawson parameter $n\tau_E$ which, as reported last year, has a maximum value of about $0.35 \times 10^{20} sec\text{-}m^{-3}$, a value slightly in excess of that required for energy breakeven at higher temperature. Further experiments aimed at advancing the Lawson parameter at plasma currents approaching 1 MA are scheduled for the coming year.

RF Heating and Current Drive: Substantial progress has been made in the second phase of the Alcator C experimental program, namely, the use of high power radio frequency (RF) waves to raise the plasma temperature, and to develop the concept of RF current drive. In experiments carried out during the past year, two sixteen-waveguide-array antennae have been used to couple over 1 MW of RF power at 4.6 GHz into Alcator C over a wide range of densities. In the density range of $1 \times 10^{13} \lesssim \bar{n}(cm^{-3}) \lesssim 1 \times 10^{14}$, RF-generated toroidal currents of the order of $I \simeq 200$ kA have been observed for time durations of up to half a second. This is achieved by launching travelling waves and preferentially heating high energy electrons with energies up to a few hundred keV. RF current generation in Alcator C is achieved at record density

levels because of the high frequencies chosen for the microwave sources. For example, in the PLT tokamak at Princeton where 0.8 GHz frequency sources were chosen, flattop toroidal currents could be generated only at densities below $1 \times 10^{13}cm^{-3}$. Our results have attracted world-wide attention and resulted in a number of invited talks at various national and international conferences.

When the density is raised to the regime $1 \times 10^{14} < \bar{n}(cm^{3}) \lesssim 2 \times 10^{14}$, and the waveguide arrays are phased so as to produce a standing wave at the waveguide mouths, significant plasma heating is observed. Initial measurements indicate that by injecting 850 kW of RF power at the reactor relevant density of $\bar{n} \simeq 1.5 \times 10^{14}cm^{-3}$, the electron temperature was raised from $T_e \simeq 2.0$ keV to values $T_e \gtrsim 3.0$ keV, and the ion temperature was raised from $T_i \simeq 1.1$ keV to 1.9 keV. These results, which were obtained by using SiC coated carbon limiters, correspond to a heating rate of $n(\Delta T_e + \Delta T_i) \gtrsim 20$ eV $\times 10^{13}cm^{-3}/kW$, a record value. In fact, no other experiment with any type of heating technique has previously produced such a significant heating at the high density typical of these experiments. We note that at the same time there is significant increase in the plasma impurity level. However, our experiments operate at record surface power flux levels which approach (within a factor of two) the expected equivalent thermal flux in a reactor. These results, therefore, indicate the necessity of active impurity control in future reactor-grade plasma devices.

We are preparing two additional 16 waveguide arrays to inject up to 2 MW of RF power early next year. Assuming that the impurity influx can be controlled, we expect to further increase the RF currents generated, and further increase the electron and ion temperature rise. Meanwhile, a 600 kW ICRH (ion cyclotron resonance frequency) experiment operating at 186 MHz (2nd proton cyclotron harmonic) is being prepared for installation in Alcator C later this year. This system combines one of the lower-hybrid power supply (modulator) units, and the FPS-17 radar system donated to the Plasma Fusion Center by the U.S. Air Force.

Advanced Toroidal Development: Design work during the past year has centered on the Alcator DCT tokamak concept, a long-pulse/steady-state superconducting device which will address physics and technology issues critical to the realization of a continuous or quasi-continuous toroidal reactor. The objectives of the program include plasma shape and profile control during long-pulse and steady-state operation with reactor relevant power loading, and optimization of non-inductive (RF) current drive techniques and RF heating with reactor-level plasma parameters. In the technology area, the design provides integration of superconducting magnet systems in an operating tokamak environment and serves as a focus for development and testing of first wall, limiter and divertor materials and configurations.

The Alcator DCT device features a fully superconducting magnet system utilizing Nb_3Sn toroidal field coils and NbTi poloidal field coils. The elongated cross section incorporates an external coil poloidal divertor. The toroidal field on axis is 7 tesla, corresponding to 10 tesla at the coil, while the poloidal field system provides a flux swing of 35 volt-seconds, permitting inductively-driven pulse lengths of several minutes. The RF system includes 5 MW of CW power at 200 MHz for ICRH heating and 4 MW at 4.6 GHz for lower hybrid heating and current drive. The plasma major and minor radii are 2 meters and 0.40 meters respectively, with an elongation capability of approximately 1.5. The design has been favorably received at informal reviews and presentations, and a formal proposal is being prepared for submission to the Department of Energy.

MIRROR CONFINEMENT EXPERIMENTS

The Mirror Confinement Systems Division, headed by Dr. Richard S. Post, is involved in the design, construction and operation of a medium-scale tandem mirror research facility called TARA. The main objective of this research program is to develop an increased understanding of basic tandem mirror physics with emphasis on microstability properties, thermal barrier formation and RF heating. The primary research areas include: confinement physics (Richard Post); TARA engineering (D. Bruce Montgomery and Richard Post); and computations and advanced concepts (Jay Kesner). Richard Post and Jay Kesner are overall TARA program principal investigators.

TARA Tandem Mirror: The Tara tandem mirror facility, located in the west wing of the PFC Nabisco Laboratory (NW21), will begin operation in December, 1983. The overall fabrication project, including design, construction, and preparation for operation is a two-year, $14.9 million effort funded by the Department of Energy. The project includes substantial site preparation in addition to fabrication of the experimental facility and all of the subsystems such as magnet power, vacuum systems, neutral beams, RF heating systems, diagnostics, and data systems and controls. This project remains within the original cost estimate and has experienced a schedule slip of only one month, caused by a delay in completion of the site preparation.

The configuration of the TARA tandem mirror is unique in that it utilizes an axisymmetric confining plug with an outboard minimum-B anchor. This has been identified as a very desirable tandem mirror configuration for potential reactor applications. The primary objectives of the TARA experiment are to test

trapped-particle mode stability, overall MHD stability limits, central cell radial transport, and enhanced potential formation. The experiment will provide data for the proposed upgrade of the MFTF-B tandem mirror facility under construction at Lawrence Livermore National Laboratory (LLNL). The use of an MHD anchor which is well separated from the central cell ions will allow TARA to investigate the theoretically predicted tandem mirror trapped-particle instability for certain operating parameters. By varying parameters to determine regions of stable operation, TARA will supply much needed experimental data on this important class of instabilities.

The following is a brief summary of the TARA design. The TARA central cell is a 15 cm radius, 10 m long solenoid with upgrade capabilities to 15 m. When a thermal barrier is present, the projected plasma parameters are $T_e \sim T_i \sim 400$ eV and $n \simeq 4 \times 10^{12} cm^{-3}$. Ions are confined by axisymmetric plugs which eliminate the possibility of enhanced radial transport that is driven by the quadrupole moments of the plugs (so-called "resonant" transport).

The central solenoid is bounded by high-mirror-ratio plugs (R = 5 to 10) with peak fields of up to 5 T. Neutral beams (20 keV extractor energy) with 150 A current are injected at a 40° angle into the plugs to create a sloshing-ion distribution which is expected to exhibit improved microstability properties and provide a partial thermal barrier. Gyrotrons at 28 GHz are available with a capability of 200 kW per plug for creating the hot mirror-trapped thermal barrier electron species and the suprathermal ($T_e \sim 700$ eV) warm electron species. Thus, a thermal barrier is expected to form at the midplane of the plugs.

A unique feature of the TARA configuration, and one that provides a substantial reduction in cost and technology requirements is the use of RF-driven MHD anchors. The anchor will be formed in externally located baseball coils that were formerly the plugs in the TMX experiment at LLNL. They will operate steady-state and contain a low-density ($n \sim 5 \times 10^{11} cm^{-3}$) hot-electron plasma, formed by ECRH heating in the X-band. Additional ion heating utilizing ICRH will be used to augment beta values in the anchor.

During the past year, construction of the major hardware components for TARA has been completed, including vacuum chambers, magnets, and the magnet power substation. Site preparation, which includes substantial modifications of the west wing of the Nabisco Laboratory (NW21), is now essentially complete. The recent completion of the cell area has allowed installation of the major vacuum chambers, magnets and support structures for the TARA experiment. The assembly, alignment, and leak testing of the device will continue through November, 1983, with initial operation scheuled for December, 1983. Development of the principal subsystems required to operate the experiment (such as diagnostics, radio frequency heating, programmable controls and data acquisition) has also proceeded on schedule during the past year.

Tandem Mirror Theory: Theoretical work during the past year has been in the areas of the trapped-particle instability mentioned above, plug microstability, enhancement of the plug confining potential beyond the thermal (Boltzmann) regime, and antenna modeling for ion cyclotron heating. This research is described briefly below.

The initial theory of the trapped-particle instability assumed a high mode number and ignored rotation and collisionality. We have extended this theory to include rotation and collisionality for arbitrary azimuthal mode numbers. Results of this work indicate that with proper potential control TARA can be operated in a regime that is stable to trapped-particle modes without compromising the simplicity of the geometry. The key to this stability is the generation of a stabilizing Coriolis force that arises when the radial equilibrium electric field is small and points inward. The theory indicates that a new instability, a rotationally-driven trapped-particle mode, is present unless the radial potential variation is small (compared to T_e).

To gain a better understanding of microinstability for mirror confined hot ions, a code has been developed that solves for the axial eigenmodes of the drift cyclotron loss cone (DCLC) and axial loss cone (ALC) instabilities. This code can also perform radial ray tracing to determine radial eignemodes, and will be valuable in predicting and analyzing experimental results.

In addition, we have analyzed two schemes for plug potential enhancement. The first approach is the axicell thermal barrier. An electron Fokker-Planck code is being developed for detailed predictions of potential enhancement resulting from strong ECRH diffusion. In addition, this code will be consistent with ECRH ray tracing models. A second approach to potential enhancement would make use of electron pumping. This approach tends to be more stable to the trapped-particle mode than the thermal barrier approach. We have found that strong parallel electron heating can result from RF in the electron bounce frequency range (which is close to the ion cyclotron frequency range). The evaluation of power and efficiency is being pursued through the use of both Monte Carlo and Fokker-Planck techniques.

The TARA experiment will rely on ICRH for start-up and central cell power balance, maintenance of a finite beta ion population in the anchor, as well as radial and axial potential control. This will require a detailed understanding of RF amplitudes and profiles. With this in mind, we have continued to develop more sophisticated and versatile antenna-plasma coupling codes. The present antenna coupling code can now

model a wide variety of antenna surrounding a cylindrical plasma. Using a stratification technique, the influence of radial plasma density profiles on wave propagation and power deposition can be studied.

Finally, experimental work has been primarily in the area of fusion related vacuum technology. Experiments with niobium gettering have proven particularly successful, demonstrating a much higher pumping capacity than conventional titanium gettering. The application of supersonic magnesium jets to control gas flow from neutral beam sources is also being evaluated.

APPLIED PHYSICS RESEARCH

The primary objective of the Plasma Fusion Center Applied Physics Research Division, headed by Professor Ronald Davidson, is to develop the basic experimental and theoretical understanding of plasma heating and confinement properties. Present applied physics research activities include: experimental research on the Versator II tokamak (Professors George Bekefi, Miklos Porkolab, and Dr. Stan Luckhardt); experimental research on the Constance mirror device (Dr. Richard Post and Professor Louis Smullin); fusion theory and computations (Professors Abraham Bers, Bruno Coppi, Ronald Davidson, Thomas Dupree, Jeffrey Freidberg, Dennis Hewitt, James McCune, Kim Molvig, and Dr. Jay Kesner); development of the MACSYMA symbolic manipulation system (Professor Joel Moses); plasma diagnostics and laser development (Drs. Daniel Cohn and Paul Woskoboinikow); and basic experimental and theoretical research on radiation generation by intense charged particle beams (Professors Bekefi and Davidson).

We summarize here the significant progress made during the past year in selected applied plasma physics research areas.

Versator II is a medium-size research tokamak (major radius = 40.5 cm; minor radius = 13 cm; toroidal magnetic field = 15 kG) with primary emphasis on basic investigations of RF plasma heating and current drive. During the past year, a series of experiments have been carried out testing the interaction of lower-hybrid waves, in various density regimes, with electrons and ions. In the low density regime ($\bar{n} < 10^{13}cm^{-3}$) traveling lower-hybrid waves launched from a phased array of waveguides can impart net momentum to plasma electrons thereby generating a plasma current. Such wave-generated currents may eventually be used to drive the current in a steady-state tokamak fusion reactor.

X-ray spectroscopic measurements on Versator II have shown that wave absorption generates suprathermal energetic electron components in the energy range 10-100 keV >> $T_e \sim 0.4$ keV, and that this electron component is generated near the center of the plasma cross section in qualitative agreement with theoretical predictions of the wave-electron interaction.

The confinement of particles in tokamaks has loss rates 10-100 times those predicted by collisional transport theory. This anomaly is one of the outstanding unsolved problems in plasma physics. The Versator II current drive experiments have recently shown that the particle confinement in discharges with RF-driven currents is improved by at least a factor of two relative to discharges with ohmically driven currents. Further experimentation is required to identify the mechanism for the improved confinement.

In the higher density regime ($\bar{n} \gtrsim 2 \times 10^{13}cm^{-3}$), the dispersion of the lower-hybrid wave allows direct interaction and absorption of the wave by the ion component. In Versator II, such wave-ion interaction has been observed experimentally. Ion heating with temperature increase of 40% (ΔT_i = 50 eV) has been obtained by injecting 50 kW of power at f = 800 MHz through a four-waveguide array. Further experimentation is required to clarify the heating process.

The theory of lower-hybrid wave propagation in a toroidal plasma predicts that waves launched from the top of the torus will be more efficiently absorbed than those launched from the midplane. Previous experiments have used midplane couplers due to space limitations. Recently, however, a four-waveguide top-launching coupler has been constructed and installed on Versator II. The technological problems associated with high-power operation of this antenna array have been overcome by coating the vacuum surfaces of the antenna with carbon to minimize secondary electron production. The power transmission of the antenna without carbon coating was limited to 15 kW by breakdown in the waveguides. After carbon coating and RF processing to remove hydrogen from the surface, up to 100 kW has been successfully coupled to the plasma with this antenna. High-power experiments are now underway with the top coupler.

During the past year, three graduate students have completed their thesis research on Versator II, and planning for two future experiments has been carried out. Construction has begun on a new power system for Versator II which will allow tokamak operation with current supported by RF current drive only. The new system will initiate the tokamak discharge with an inductively-driven current, then allow for a fully RF-driven phase where the current will be supported by RF alone.

Construction of a lower-hybrid RF system at higher frequency (f = 2.45 GHz) is also underway. The purpose of the new system is to drive current in higher density plasma ($\bar{n} \gtrsim 10^{13}cm^{-3}$) than is possible with the present 800 MHz system, thereby testing the frequency dependence of the current-drive mechanism.

The Constance research effort during the past year has concentrated on the design and construction of the new Constance A and B mirror facilities in the Nabisco Laboratory (NW21). Constance B, a quadrupole mirror of moderate size, has been designed to study hot electron production, ion pump-out, and radial electric field control and analysis. Constance A, an upgrade of the Constance II experiment, will be concerned with similar physics issues but in axisymmetric systems. Both Constance A and B will be operational before the end of 1983.

Hot electron plasmas ($T \sim 400$ keV, $n \sim 5 \times 10^{11} cm^{-3}$) will be generated in Constance B using electron cyclotron resonant heating (ECRH). Up to 1 kW of microwave power at either 8 GHz or 11 GHz is available. Microstability properties and plasma beta will be studied as a function of the cold plasma population. A major experimental goal will be the generation of a negative ambipolar potential.

In support of both experiments, a 3-D orbit code has been developed to study RF pump-out techniques of ions at the ion bounce frequency. By applying a perpendicular magnetic field driven at the ion bounce frequency, together with the self-consistent electric field, large radial drifts in the ion motion can be produced. This process works in both symmetric and quadrupole fields and will be tested experimentally in Constance B. While theory shows a factor of ten enhancement in the radial diffusion coefficient in the quadrupole case relative to the axisymmetric case, encouraging results from Constance B will certainly warrant further work along these lines in Constance A.

Radial electric field control techniques will also be evaluated in Constance A and B. The stability of magnetic mirrors against trapped-particle modes is contingent on the ability to control the plasma radial potential profile.

During the past year, construction of an acousto-optic RF spectrometer has been completed which will allow acquisition of wide-bandwidth (500 MHz), high-resolution (1 MHz) spectra at a high repetition rate (1 spectrum every 10 microseconds). The spectrometer and its associated microwave receiver will provide spectral coverage over the frequency range from 5 MHz up to 4 GHz.

Constance II has continued to operate during the past year, completing the modulated e-beam experiments described in the 1982 report. Although some increase in diamagnetism was found, this increase was not consistent with theoretical expectations. This discrepancy is caused by the plasma interacting with the modulating structure and limiting the obtainable modulation depth.

In the plasma theory and computations area, there has been considerable technical progress during the past year in a variety of important areas. Recent studies include: (a) the continued development of self-consistent plasma models which simultaneously include the effect of neoclassical transport and plasma turbulence, (b) the formulation of a nonlinear kinetic theory of tearing modes, to explain the MHD density limit in Alcator C, (c) the investigation of the stabilizing effects of limiters on external kink mode stability, (d) the continued development of self-consistent theoretical models describing anomalous electron energy transport in tokamaks, (e) basic investigations of the MHD stability properties of tokamak plasmas and the determination of stable operating regimes at moderate values of plasma beta (the ratio of plasma pressure to magnetic pressure), (f) the development of a self-consistent kinetic description of the free electron laser instability including the important influence of novel magnetic field configurations and finite radial geometry, (g) continued basic theoretical investigations of RF heating, including studies of steady RF current drive and computational studies of the nonlinear coupling of microwave power to the plasma from waveguide arrays, (h) development of a 2-D self-consistent model of RF current drive with lower hybrid waves that shows a large (one to two orders-of-magnitude) enhancement of perpendicular temperature of the current carrying electrons, (i) studies of the thermal stability of ignited plasmas, (j) fundamental nonlinear studies of the influence of stochastic magnetic fields on turbulent transport in high-temperature plasmas, and (k) basic studies relating to the equilibrium, stability and transport properties of high-field tokamak configurations using advanced fuels (e.g., D-He_3).

In the plasma diagnostic development area, a high-power 385 μm D_2O laser and a Schottky barrier diode heterodyne detector have been used on Alcator C to make the first measurements of thermal level Thomson scattering in tokamak plasmas. The scattered radiation is broadened in frequency by the Doppler shift due to the ion thermal velocity. The measured broadening was found to be consistent with other determinations of ion temperature. These measurements of thermal level Thomson scattering show the feasibility of the eventual use of Thomson scattering as a means of localized determination of ion temperature in high-temperature plasmas of interest in fusion research.

As a result of extensive experimental work, computer simulation, and theoretical studies, free electron laser research has reached a high level of maturity. At MIT, efforts have been concentrated on free electron lasers operating in the high-current (Raman) regime. Particular success has been achieved in the construction and operation of a circular free electron laser in which the electrons orbit in an azimuthally periodic magnetic field. There is also continued emphasis on developing novel concepts for coherent radiation generation.

FUSION TECHNOLOGY AND ENGINEERING

The Fusion Technology and Engineering Division, headed by Dr. D. Bruce Montgomery, provides critical engineering analysis for the advanced design projects, and develops advanced superconducting magnet technology for the national fusion program. Research activities include: engineering support for the TARA tandem mirror experiment and for proposed follow-on experiments in the PFC toroidal confinement program (D. Bruce Montgomery); advanced magnet design in support of the Fusion Engineering Design Center at Oak Ridge National Laboratory and the INTOR International Tokamak Reactor study (Joel Schultz and Dr. Richard Thome); concept development for improved magnetic divertors for tokamak and mirror upgrades and next-generation test reactors (Dr. Ted Yang); development of forced-flow superconductors for application to advanced fusion devices (Mitchell Hoenig); basic research on the development of ductile superconducting materials (Dr. Simon Foner, Professor Robert Rose and Dr. Brian Schwartz); advanced magnet design in support of DOE programs in MHD and high energy physics (Drs. Peter Marston and John Tarrh). We briefly summarize here research activities in these technology and engineering areas.

Major upgrades of the large tokamak and mirror experiments in the US are under consideration, and examination of the alternatives is the responsibility of the Fusion Engineering Design Center, an industrially-based design group located at Oak Ridge National Laboratory. The Plasma Fusion Center provides major technical support to that Center, with responsibility for a number of magnetic systems and critical design issues. Analylsis of critical magnet design issues for the international INTOR project is also carried out.

The Plasma Fusion Center has been active in developing improved magnetic divertor concepts. A long-burning fusion reactor must deal with the buildup and removal of helium "ash" and impurities, and magnetic or mechanical divertors are considered to be an extremely demanding but necessary component. Construction of a high-field divertor for the ISX-B tokamak at ORNL has been completed by the PFC. Borivoje Mikic and Neil Todreas and their students have been active participants in basic divertor studies.

Critical experimental tests are also being carried out in the development of forced-flow conductors for superconducting fusion magnets. The supercritical helium-cooled conductor, conceived and developed by the magnet group, has been selected by Westinghouse for the 2 × 3 meter niobium-tin coil for the Large Coil Project at the Oak Ridge National Laboratory. The forced-flow group will also utilize an advanced version of the conductor to build a 40 cm bore, 12 tesla insert for the High Field Test Facility at the Lawrence Livermore National Laboratory.

Basic research on advanced superconducting materials is also a major fusion engineering activity in the Plasma Fusion Center and the Materials Science and Engineering Department. The objective is to develop materials and techniques for producing superconductors capable of generating 15 tesla magnetic fields and sufficiently ductile to be suitable for advanced fusion devices. Materials developed by this group show considerable improvements in mechanical properties and offer significant possible reduction in production costs over conventional industrial preparations.

Advanced magnet design for the national MHD program, and for selected national high energy physics projects is also carried out. While the MHD program is greatly reduced from previous levels, there are several utility/industrially-based activities which show promise of growth. The design group is presently supporting activities at Southern California Edison for an MHD disk generator upgrade of an existing plant. Research by the MIT magnet design group in the high energy physics area was directed at the Isabell magnet systems during 1981-82, and is now emphasizing work on Professor S. Ting's large L3 detecter for installation at CERN.

In addition to these fusion and related technology areas, the engineering group is involved in the design and construction of the PFC confinement experiments. Advanced design activities during the past year have concentrated on conceptual design studies for a superconducting long-pulse tokamak, Alcator DCT, as a follow-on to the Alcator C experiment.

FUSION SYSTEMS

The Fusion Systems Division, headed by Dr. Daniel Cohn, investigates several aspects of fusion reactor design and develops advanced millimeter and submillimeter wave technology for plasma heating and diagnostics. Research activities include: safety and environmental studies (Professor Mujid Kazimi); reactor system studies (Drs. Daniel Cohn, Leslie Bromberg, and John Williams); blanket and first wall structural design studies (Professor John Meyer); gyrotron and advanced millimeter source development (Richard Temkin); millimeter and submillimeter detector development (Dr. Peter Tannenwald, Lincoln Laboratory).

Safety and Environmental Studies: An evaluation is being made of the impact that different first wall and blanket materials might have on the safety of a fusion plant. The radiological consequences of accident events in seven plant conceptual designs are being evaluated. The events include loss of piping integrity and loss of coolant flow capability under operational and decay-heat conditions. It has been found that the levels of activation-product inventory vary within an order-of-magnitude, while the tritium inventories in the blanket breeder could vary by three orders-of-magnitude. Accidental releases of activation products to the atmosphere from vanadium, as a structural material, are less consequential than those from steel or TZM molybdenum alloy.

An assessment has been made of the total risk to human life implied by all the activities associated with electricity generation from fusion. This includes the expected mining, manufacturing and construction activities related to the power plant as well as the operation and maintenance of the plant. The results are compared to published risk assessments for electricity generation from other sources. The total power cycle risk from fusion is found to be comparable to (if not less than) the lowest risk imposed by the alternative energy sources.

Reactor System Studies: Design concepts for commercial tokamak reactors with very long pulses have been investigated. An illustrative design has been developed for an ultra long pulse tokamak reactor (ULTR) which could provide 24-hour pulses using current which is inductively driven by the ohmic heating transformer. ULTR is somewhat larger (major radius ~ 10 m) than current commercial tokamak reactor designs and utilizes a high-performance, high-field ohmic heating transformer. Another important feature is a complete modularization of the tokamak by means of a toroidal field magnet design in which the coils are individually removeable. This concept facilitates assembly and maintenance. Parametric studies have been carried out to determine the effect of pulse length on reactor size. It is found that a device with an ULTR type magnetics system and about the same size (7.5 m in major radius) as present commercial reactor designs could provide a pulse length of four hours. The ULTR design approach provides an important alternative if a sufficiently efficient means of steady state non-inductive current drive cannot be found.

A new design concept has also been developed for a long-pulse ignited test experiment (LITE) device, a tokamak which uses high-performance resistive magnet plate technology. The physical size of LITE is similar to the Tokamak Fusion Test Reactor (TFTR) tokamak at Princeton University. However, LITE would provide mugh higher values of the density and confinement parameter $n\tau_E$ and have substantially greater long-pulse capability. The higher $n\tau_E$ capability is obtained by operation at high magnetic fields and at moderately high values of beta (the ratio of plasma pressure to magnetic field pressure). The main goals of LITE are to demonstrate ignition where the plasma heating is completely provided by fusion reaction products (alpha particles in the case of the deuterium-tritium reactor) and to study the equilibrium and stability features of self-heated plasmas.

Concepts for mirror reactors are being developed in collaboration with the TARA experimental program. Particular attention has been given to a new approach in which radio frequency pumping of electrons is used for potential barrier formation.

Blanket and First Wall Studies: A key issue in assessing the viability of the operation of a tokamak as a pulsed reactor is the effect of thermal fatigue on the first wall. An investigation of this issue has been carried out as part of an evaluation of long-pulse tokamak operation by the reactor system studies group. Effects of thermal fatigue and crack growth have been evaluated using a two-dimensional model. For a representative stainless steel first wall design it is found that thermal fatigue constraints could be prohibitive for pulse lengths of less than one hour. For a vanadium first wall, the constraints are greatly eased; it appears that pulse lengths of 30 minutes are sufficiently long for a wide range of operating conditions. In general, the two-dimensional model gives results which are significantly more limiting than those obtained with a one-dimensional thin-shell model.

Gyrotron and Advanced Millimeter Source Development: Improved power levels and efficiency have been obtained in operation of the gyrotron device (electron cyclotron maser) developed at the Plasma Fusion Center. Output powers of 100 kW at a frequency near 140 GHz have been achieved at an efficiency of 36 percent. To our knowledge, this is the highest efficiency ever achieved at any frequency above 60 GHz by a high-power coherent source, including masers or lasers. Output powers of up to 175 kW at 28 percent efficiency have also been achieved. Operation is short-pulse (1 μs), but the device appears scalable to long-pulse or even CW operation. The output bandwidth has recently been measured on a single pulse basis and is found to be less than 3 MHz. Studies have been completed on mode competition and second harmonic emission in the gyrotron. The gyrotron group has also developed a tunable far infrared laser based on stimulated Raman scattering of tunable CO_2 laser radiation in CH_3F gas. Continuous tuning between 32 and 40cm $^{-1}$ (250 to 300μm) has been achieved.

Millimeter and Submillimeter Detector Development: Schottky barrier diode detectors have been developed at Lincoln Laboratory for a variety of plasma diagnostic applications including submillimeter laser interferometry, cyclotron emission measurements and Thomson scattering measurements of ion temperature.

Improvements in detector capability have been investigated. These improvements include development of arrays, use of monolithic detector designs and harmonic mixing techniques.

APPOINTMENTS AND PROMOTION

During the past year, there have been several important appointments and promotions in Plasma Fusion Center program areas.

Appointments include: Mark Dunham (Tektronics), appointed Research Engineer in the TARA program; Thomas Fredian (DuPont), appointed systems programmer and analyst in the Alcator program; Dr. Kiriakos Hizanidis (Massachusetts Institute of Technology), appointed Postdoctoral Associate in the theory and computations group; Dr. Brian Lloyd (Culham Laboratory), appointed experimental Research Scientist in the Alcator RF heating program; Mark London (Itek Optical Systems), appointed systems programmer and analyst in the theory and computations group; Dr. Michael Mauel (Massachusetts Institute of Technology), appointed experimental Research Scientist in the TARA program; Ilene McCool (University of Texas at Austin), appointed applications programmer in the Alcator program; Dr. Donna Smatlak (Lincoln Laboratory), appointed experimental Research Scientist in the Constance experimental group; Joshua Stillerman (University of Wisconsin), appointed applications programmer in the TARA program; Dr. James Sullivan (Massachusetts Institute of Technology), appointed experimental Research Scientist in the Tara program; and Paul Thomas (High Voltage Engineering Corporation), appointed technical supervisor in the TARA program.

In the Nuclear Engineering Department, Professor Kim Molvig has been promoted to Associate Professor with tenure, and Dr. Ian Hutchinson (Culham Laboratory) has been appointed as Associate Professor with tenure.

During the past year, promotions in the Plasma Fusion Center include: Dr. Kuo-In Chen promoted to experimental Research Scientist in the Versator experimental group; Ms. Kathleen LaPier promoted to PFC Fiscal Officer in the office of resource management; Ms. Layla McKnight promoted to administrative staff supervisor in the Alcator program; Dr. Wayne McMullin promoted to theoretical Research Scientist in the charged particle beam research group; Charles Park promoted to Associate Operations Manager in the Alcator program; and Frank Silva promoted to Operations Manager in the Alcator program.

The Plasma Fusion Center has also hosted several visiting scientists in the various research programs. They are: Dr. Yuri Baranov (Ioffe Institute, USSR), toroidal confinement experiments; Dr. Johan Goedbloed (Association Euratom-Fom, Holland), MHD equilibrium and stability; Dr. Zengji Guo (Academia Sinica, P.R.C.), fusion technology and engineering; Professor Hiroshi Kikuchi (Nihon University, Japan), mirror plasma research; Dr. Ren-Jun Li (Academia Sinica, P.R.C.), plasma formation in relativistic diodes; Dr. Igor Popov (Kurchatov Institute, USSR), toroidal confinement experiments; Dr. Yashushi Terumichi (Kyoto University, Japan), lower hybrid heating and current drive experiments; Dr. Yuan-Zhao Yin (Academia Sinica, P.R.C.), millimeter and submillimeter wave radiation problems; Dr. Hong Zhang (Academia Sinica, P.R.C.), superconducting materials development; and Dr. Arie Zigler (INESCO), diagnostics for toroidal confinement experiments.

RONALD C. DAVIDSON

Research Laboratory of Electronics

The Research Laboratory of Electronics (RLE) is an on-campus research environment which provides faculty members and their students with the diverse services and facilities of a large laboratory. RLE was established at the end of World War II as the Institute's first interdepartmental laboratory. It was originally organized to encourage interactions between teaching and research in the Departments of Electrical Engineering and Physics but has subsequently had projects involving participants from as many as a dozen academic departments. The research groups, which currently number approximately 27, conduct studies in three broad areas: general physics, plasma dynamics, and communication sciences.

Research in RLE is primarily performed by faculty members, postdoctoral staff, and students. Approximately 75 members of the faculty are affiliated with the Laboratory and work with about 210 graduate students and 100 undergraduates. The research covers many topics, thus providing opportunities for a wide variety of student theses. During the past year, work done in the Laboratory served as the basis for 19 doctoral, two engineer's, 10 master's, and 11 bachelor's theses.

Major support for the research is provided by the Joint Services Electronics Program of the Army, Navy, and Air Force, as well as other agencies of the Department of Defense, the Department of Energy (DOE), the National Science Foundation, the National Institute of Health, the National Aeronautics and Space Administration, industry and foundations.

GENERAL PHYSICS

The general physics area contains such subjects as solid state and atomic physics, quantum electronics, and electromagnetics. The Laboratory's research in general physics is primarily concerned with the structure of matter -- atoms, molecules, and condensed matter. The experimental techniques used in these investigations include radio frequency and optical spectroscopy, X-ray scattering, laser light scattering, photo-acoustic spectroscopy, and nonlinear optics.

The Submicron Structures Laboratory, under the direction of Professor Henry I. Smith and Principal Research Scientist John Melngailis, is developing techniques for fabricating surface structures of nanometer to micrometer linewidths and using these structures in a variety of research projects. This laboratory contributes to an expansion of microsystems research at MIT. Submicron structures fabrication has become a distinct discipline with a world-wide and growing community of practitioners. Fabrication techniques include various forms of lithography (optical, electron beam, x-ray, ion beam), etching (aqueous, reactive plasma, sputtering), growth (oxidation, plating, epitaxy) and deposition (evaporation, chemical deposition, sputtering). With these techniques it is possible to fabricate experimental structures with minimum feature sizes smaller than certain characteristic distances important in a variety of scientific fields (e.g., coherence length, mean-free-path, wavelength, grain size, domain size, living-cell diameter). For example, metal wires with widths below 10 nm can be fabricated, and electrical conduction in such structures studied. New insights are needed to understand the behavior of matter at such small dimensions. Although the scientific applications at small dimensions have motivated some of the research on submicron structure fabrication, the main driving force has come from the integrated circuits industry. Much activity is aimed at developing the technology and the scientific understanding that will bring integrated electronic devices into the submicron domain. The hope is that this will lead to systems of higher performance.

Activity in the area of optics and quantum electronics continued to expand. Professors Hermann A. Haus and Erich P. Ippen and their students have been developing novel waveguide optic devices for ultra-high-speed signal processing and new lasers for studies of material processes on a sub-picosecond timescale. The goal of the research is to develop prototype optical waveguide devices that operate at rates of many tens of Gigahertz. Such devices can be driven either electrically, by microwave oscillators, or optically. Waveguide optics, or the more ambitiously named Integrated Optics, will not compete seriously with integrated electronics in all those functions that can be performed electronically. Optical devices have a more demanding topology (e.g., optical waveguides have transverse dimensions of several optical wavelengths and do not permit sharp bends) and higher power requirements. However, waveguide optics can perform certain signal processing functions at greater speeds than electronic circuits. High speed signal processing is one application in which waveguide optics can seriously compete with electronics. Professors Haus and Ippen have extended and refined their analytical model for pulse shaping and shortening in passively modelocked dye lasers and semiconductor lasers. Last year this model was developed to include, in modelocking theory, the effects of coherent pulse coupling in colliding-pulse ring lasers. As a result of numerical studies based on the model, they were able this year to introduce the concept of 'pulse shortening velocity' (PSV) as an accurate and practical measure of modelocked laser performance. With PSV we have, for the first time, a straightforward description for shorter pulses that includes coherent coupling and illuminates the effects of different types of resonator dispersion. A

paper on the subject has been accepted for publication in the IEEE Journal of Quantum Electronics. Work progressed significantly this year in the development of a picosecond dye laser source for the GaAlAs bandedge regime. By the end of this year application to studies of picosecond saturation in GaAlAs waveguides will also have begun. Our future work will be aimed at producing a waveguide logic gate in GaAs. We are also investigating nonlinear processes with higher nonlinearities than those attributed to insulated bulk GaAs, e.g. optical hole-electron generation. Such processes have relaxation times of nanoseconds and as such are not usable for picosecond devices. However, there are several possibilities for increasing the relaxation rates which would make them applicable to picosecond signal processing at power levels available from semiconductor lasers.

Professor J. David Litster and his students are using time-resolved spectroscopy in conjunction with light scattering and X-ray scattering to study the properties of condensed phases of matter. Their goal is to understand why large numbers of interacting particles form the phases which they do and why they have the properties they have. Phase transition is one of the most important problems of current interest in physics.

Professor Robert J. Birgeneau and his collaborators continued their studies of phase diagrams, structures, and structural phase transitions of several model systems, including molecular oxygen and krypton and xenon physisorbed onto the basal planes of ZYX exfoliated graphite. Modern X-ray scattering techniques are used to study the structures and phase transitions in novel states of condensed matter. The group has two principal experimental facilities. At MIT they have three high-resolution computer controlled X-ray spectrometers using either a conventional or high intensity rotating anode X-ray generator. They are also currently installing a two spectrometer system at the National Synchrontron Light Source at Brookhaven National Laboratory. This makes possible high resolution scattering experiments with a flux more than three orders of magnitude larger than that from a rotating anode X-ray generator. This opens up a new generation of experiments. Synchrotron X-ray scattering experiments are also carried out on a wiggler beam line at the Stanford Synchrotron Radiation Laboratory, where the group is designing and building an X-ray compatible high vacuum single crystal surface apparatus. This will enable them to use synchrotron radiation to study the structure and transitions occurring at single surfaces. The possibilities with this seem virtually unlimited. Current experiments in this program are concentrated in two areas: (i) the growth, structure, and phase transitions of intercalant materials, most especially bromine-intercalated graphite, (ii) the structure and phase transitions of smectic liquid crystals.

The measurements of photoluminescence (PL) in amorphous SiO_2 by Professor Marc Kastner's group have demonstrated that there are several separate PL spectral bands associated with atomic-scale defects. One major goal of their current research is to determine which of the several PL bands observed arises at the same and which at different PL centers. To do this they are carrying out time-resolved PL measurements at a variety of temperatures for a SiO_2 prepared in a number of different ways. The time-resolved spectroscopy allows them to unambiguously identify PL bands by their different decay rates. The temperature dependence of the PL decay is important because it can provide information about whether two different PL bands can originate at the same defect. The excitation-energy dependence of the intensity of the various PL bands will also help to differentiate among PL centers. The group has also begun studies on thermally grown oxide films. Theoretical work on the interpretation of such photoconductivity experiments has led to interesting predictions for the experiments.

Professor Jin Au Kong and his students continued studies of electromagnetic waves with application to microstrip antenna and microwave integrated-circuit problems, geophysical subsurface probing, microwave remote sensing, and optical-beam diffraction by periodic structures. Microstrip antenna and microwave integrated-circuit problems were carried out with rigorous analytical approaches. Solutions for scattering by periodic rough surfaces were applied to optical as well as microwave frequencies. Extensive work has been accomplished in the development of theoretical models that account for absorption, scattering, layering, and rough surface effects of earth terrain. Electromagnetic wave scattering and emission from periodic surfaces have been solved using a rigorous model theory. The results satisfy the principles of reciprocity and energy conservation and include shadowing and multiple scattering effects. Active and passive remote sensing of atmospheric precipitation is studied with the vector radiative transfer equations. Electromagnetic wave scattering from a layer of random discrete scatterers has been studied with the strong fluctuation theory and the quantum mechanical potential approach.

Professor Frederic Morgenthaler continues research on localized magnetostatic modes. Microwave magnetics technology is being called upon to provide analog signal processing capabilities directly at microwave frequencies and also to create electronically tunable nanosecond time delays for phased-array antennas. The goal of this research is to achieve a synthesis procedure that will allow device characteristics to be realized to exacting standards and to develop an understanding of electromagnetic, magnetostatic, and magnetoelastic wave phenomena and to employ them to create novel device concepts useful for microwave signal-processing applications. He is especially interested in developing novel device concepts for the millimeter wavelength portion of the electromagnetic spectrum.

Professor Shaoul Ezekiel and his students devoted their research studies to the interaction of two laser fields with a three-level system in an atomic beam. Of particular interest was the basic study of coherent

two-photon excitations for various configurations of the three levels in the system. They investigated both weak and intense field excitations and fit the data to theoretical predictions. The data in vapors showed strong evidence of nonlinear optical effects, such as self-focusing, even in very low pressures.

Professor John D. Joannopoulos' group continued theoretical studies of semiconductor surfaces and defects. During the past year, they developed a method of calculating the total ground-state energy of a surface system from first principles to provide accurate theoretical predictions of surface geometries. Preliminary results of metal atoms deposited on a semiconductor surface look very promising. The first total energy map for an interacting atom-surface system has been obtained. The map clearly illustrates possible chemisorption sites as well as specific migration or diffusion channels.

Professor David H. Staelin and his students completed a study of optimum satellite communication network achitectures which provides insight into least-cost mixtures of satellites and terrestrial networks and into the proper choice of many other system parameters. Dr. Philip W. Rosenkranz, graduate student Krishna Nathan, and Professor Staelin discovered that retrievals of global atmospheric temperature fields based on microwave data from operational meteorological satellites could be usefully improved by incorporation of three-dimensional statistics instead of the one-dimensional statistics presently employed. Professor Staelin, Dr. Rosenkranz, and their students have also discovered that certain repetitive features in the Jovian decametric radio emissions occur too frequently to be readily consistent with simple Alfvén waves in the Jovian magnetosphere; the inferred high Alfvén velocities suggest the toroidal magnetic fields associated with the Alfvén currents may exceed the ambient magnetic field sufficiently to induce instabilities in these currents, which may also explain other anomalous oscillations evident in the same radio emission data. Professor Staelin, Dr. Michael Shao, and graduate student Mark Colavita operated successfully for the first time the Mark-II astrometric interferometer at Mount Wilson Observatory. The successful tracking of stellar fringes simultaneously in the red and blue portions of the visible spectrum was a key milestone in this effort to develop astrometric techniques for achieving 10^{-4} arc sec relative accuracy from ground-based observations, which is adequate for planetary detection.

Professor Bernard Burke's analysis of X-ray emission from X-ray pulsars and bursters continues to be a valuable source of new knowledge about the properties of neutron stars and black holes, and about the evolution of the close binary systems in which these end products of stellar evolution are observed by virtue of the X-rays they emit as they accrete matter from their companion stars. The orbital elements of the binary X-ray pulsars LMC X-4 and 3S 1553-542 have recently been determined with high precision by analysis of archival SAS-3 data on the Doppler variation in their pulse frequencies. Studies of SAS-3 data on X-ray bursters have shown that the X-ray photospheric radius of a neutron star may increase substantially during an X-ray burst, a result that has stimulated new theoretical work on the mechanisms of non-equilibrium radiative transfer in a thermonuclear flash on the surface of a neutron star. Parallel with these and other observational studies of X-ray emitting close binary systems is an on-going theoretical study which has elucidated the evolution of low-mass binaries with particular application to the interpretation of the phenomenology of cataclysmic variables and binary X-ray sources of Population II. Steady progress has been achieved in the program of identification and study of the optical counterparts of X-ray sources whose positions have been determined with high accuracy by the modulation collimator experiment on the HEAO-1 satellite. Many candidate ultra-blue objects, located in the positional error boxes of the X-ray sources, have been found through detailed spectroscopic analysis to be distant Seyfert galaxies or quasars. Continuing analysis of high-resolution X-ray spectroscopy data from the Einstein X-Ray Observatory has demonstrated the existence of conditions of ionization disequilibrium in the Cygnus Loop and Tycho supernova remnants, and substantial abundance anomalies in Tycho and N132D, the latter being a supernova remnant in the Large Magellanic Cloud. This and other results derived from the MIT Focal Plane Crystal Spectrometer on the Einstein Observatory have established high resolution X-ray spectroscopy as a powerful method of analysis of the composition and physical properties of ultra-hot plasmas encountered in galactic and extragalactic astronomy. Evidence has been found of more optical counterparts of gamma-ray bursts in a comprehensive search of archival photographic plates. Meanwhile work is proceeding on development of an Explosive Transient Camera that is designed to record directly the optical flashes that may accompany gamma-ray bursts.

Professor Alan H. Barrett and his students studied the molecular cloud believed to be associated with the center of our galaxy. Radio astronomical facilities in Massachusetts, Arizona, and New Mexico have been utilized to observe the spectral lines of ammonia, carbon monoxide, and isocyanic acid covering a wavelength range from 0.3 - 1.3 cm. The observations reveal that the total gas density in the cloud may be a factor of 10 higher than supposed, implying a total mass of the cloud correspondingly larger. Observations with the Very Large Array provide an angular resolution of the order of one second of arc and show that the cloud is actually composed of as many as 10 individual condensations, which are regions of higher temperature or density than the surrounding cloud material.

Professor Daniel Kleppner and his group obtained new results in a study of spontaneous radiation from excited atoms. Spontaneous emission is often regarded as being stimulated by zero-point fluctuations in the radiation field. It was discovered that these fluctuations can be reduced and the spontaneous radiation inhibited by placing the atoms in a suitably mistuned cavity. Spontaneous emission is the most

elementary irreversible process in nature and is the fundamental source of noise in quantum electronic devices. The ability to control this radiation has important practical implications. It should also be possible to enhance the zero-point fluctuations in a cavity; experiments to demonstrate this are in progress. This research provides new opportunities to study novel phenomena in quantum electrodynamics, quantum optics, and coherence theory. The most probable inelastic collision between a molecule and an atom is rotationally inelastic but vibrationally elastic; only the rotational quantum number of the molecule changes from j_i to j_f. For years these collisions have been referred to as energy transfer collisions, yet in the last year new experimental and theoretical results from Professor David Pritchard's group have shown that angular momentum transfer is the more important physical variable. In this dynamical view, cross sections for excitation of an initially non-spinning molecule are calculated from the long-range atom-molecule interaction using a simple classical theory which has demonstrated ∿30 percent accuracy. The success of these theories in explaining the velocity-dependent cross sections is strong evidence of their ultimate validity and utility. In revealing the nature of the interaction of intense radiation fields on atomic systems, their experiment resolves a controversy apparent in the many relevant theoretical publications of the last few years. This, and a state-of-the-art neutral atom detector, has enabled them to display phenomena previously unobserved: a symmetric splitting of the atomic beam and a periodic modulation of 2 k in the momentum distribution. The observed magnitude of the splitting as a function of the field strength has enabled them to apply certain semiclassical theories to their data with success.

PLASMA DYNAMICS

The Plasma dynamics program seeks to understand the basic properties of ionized media in regimes that are of interest to controlled fusion, space physics, and astrophysics. Research in this area includes studies of plasma turbulence, heating, confinement, and stability. The Plasma dynamics research program in RLE is operated in conjunction with MIT's Plasma Fusion Center (PFC). Staff members hold joint appointments, and DOE support for this work is provided by contracts set up under PFC.

Professor Abraham Bers and his research group continued their studies of plasma heating for achieving energy generation by nuclear fusion. Plasmas can be heated with the electromagnetic power converted to random kinetic energy of the plasma particles. Such heating is known generically as "RF heating." The studies included analyses of RF-driven steady-state currents for confining a toroidal plasma - a problem of importance for achieving a continuously operational, tokamak-type reactor which has been addressed previously. A study was completed which proposes a novel way of using RF heating to achieve a stable, subignited fusion reactor operation with appreciable output power. The past year has witnessed a major breakthrough in experiments on current drive in tokamak plasmas with externally excited lower-hybrid waves. The two outstanding results were from the Princeton PLT group. In both experiments the currents are carried by very energetic electrons a hundred times, or more, the bulk plasma temperature. In addition, both experiments show that the current carrying electrons have a large spread in their energies perpendicular to the magnetic field, i.e. effective perpendicular temperatures that are 50 - 100 times the bulk plasma temperature. Both of these features were not foreseen, and cannot be adequately described, by presently available theoretical models. We have initiated theoretical work and computations aimed at a proper two-dimensional (velocity-space) description of RF current drive including relativistic dynamics of the current-carrying electrons.

Professor Bruno Coppi's research program focused on the combined experimental and theoretical investigation of plasmas in which fusion reactions have a significant influence on their thermal energy balance. The characteristic line of interest for this group centers on plasma with relatively high densities. The experimental devices they have developed are represented by the prototype Alcator A machine, which is characterized by toroidal plasma columns that can sustain both high currents and current densities. This requirement, leading to adoption of toroidal magnet configurations of compact size and relatively high fields, has made it possible to achieve and maintain record values for the combined confinement parameters "$n\tau_T$", the product of the peak particle pressure nT and the energy replacement τ. In addition, a sequence of plasma regimes of basic physical interest, in terms of the different characteristics of the electron distribution in velocity space and of the collective modes that are excited, has been produced. Plasma regimes of thermonuclear interest that are nearly impurity-free have been realized at the same time.

Professor George Bekefi's research focuses on experimental and theoretical studies of generating intense, coherent electromagnetic radiation in the microwave and submillimeter wavelength range, by energy conversion of relativistic electron beams. Three major types of systems are under investigation: relativistic magnetrons, gyrotrons, and free electron lasers. Three pulsed, high-voltage accelerators capable of delivering up to 50 KA of current at 0.5 to 1.5 MV are used in the experiments. The research being carried out focuses on some of the basic issues in the development of free electron sources: the interaction of electron beams with different wiggler field geometries, resonant efficiency enhancement in the presence of a uniform guiding magnetic field, effects of beams emittance and velocity spread on the interaction and the development of cross-field free electron lasers. In addition, the physics of high current field emission diodes which are commonly used as electron sources for intense beams is being studied. Many theoretical studies have been devoted to free electron lasers comprised of an electron

stream traversing a periodic, circularly polarized magnetic (wiggler) field, as can be generated with bifilar, helical, current-carrying wires. The electron dynamics in these systems exhibit simple properties that have considerable theoretical appeal. Studies of free electron lasers have begun in which the electron beam is subjected to a periodic, linearly polarized transverse magnetic field such as can be produced, for example by an assembly of permanent magnets. The use of samarium-cobalt as the magnet material has led to a new generation of magnetic wiggler systems. Their experimental and theoretical studies are concerned with a low voltage free electron laser in which the electron beam is guided by an axial magnetic field and is perturbed by a linearly polarized samarium-cobalt wiggler field. When the free electron laser is fully operational, microwave radiation at a frequency of approximately 6 GHz will be measured using crystal detectors. Power and frequency measurements will be made with heterodyning techniques. Measurements of the microwave radiation and the electron ballistics will be made simultaneously, enabling correlations between the two to be accurately investigated. All measurements will be carried out for a variety of experimental parameters, including wiggler strength, radiation polarization, and proximity to resonance.

COMMUNICATION SCIENCES AND ENGINEERING

Research in communication sciences and engineering involves fundamental studies of signals and systems and such applications as speech and picture transmission, seismic detection, and optical communication. Much of the effort is related to the life sciences. There is a combined program of research and training in communications biophysics, neurophysiology, cognitive information processing, and speech communication. Much of this work concerns sensory or perceptual mechanisms.

During the past year, the Neurophysiology Group under the direction of Dr. Jerome Y. Lettvin has produced the following studies: Together with Dr. Edward R. Gruberg, foundations were made to show that the electrical reception recorded in the cortex of the frog tectum was not generated by the entering fibers but, rather, by patches on the dendrites on which they terminate. These responses do not travel down the dendrites. With Professor Campbell Searle, Dr. Lettvin has been able to take the theory of nerve membrane to a point at which the electromechanical operation postulated by the membrane is sufficient to account for the electrical data obtained from voltage clamping. Together with Ms. Lynette Linden (College of Engineering, Boston University), Dr. Lettvin has proposed a new theory of color constancy. Dr. George Plotkin has begun a study of the differential capacitance of biomolecular leaflets, one side of which is bathed in calcium solution. Mr. Gad Geiger has been studying textural effects on object perception in the periphery of visual field and has proceeded further with his work on the biophysics of vision in the house fly. Dr. Stephen Raymond has a study of the effects of lithium on the threshold of peripheral nerve which will require an explanation at present not easily made. Dr. Plotkin and Dr. Lettvin, with the collaboration of Eric Prenowitz, re-verified the phonemic response of certain auditory components in the 8th nerve of the frog.

Professors William T. Peake, Thomas F. Weiss, William M. Siebert, and Dr. Nelson Y. Kiang's studies of the auditory system have continued in cooperation with the Eaton-Peabody Laboratory at the Massachusetts Eye and Ear Infirmary. Projects that were completed during 1982 included measurements of the input impedance of the cat cochlea to evaluate signal transmission through middle-ears and to relate middle-ear function to structural features. They now have rather extensive measurements in one mammalian species (cat) and one reptile (alligator lizard). They plan to extend these techniques to a broader range of vertebrate species to determine the effects of gross structural differences. Investigations of mechanoelectric transduction in the inner ear continue to be focused on the alligator lizard ear because of its technical and conceptual simplicity. These studies have led to a novel hypothesis about the frequency selective mechanisms of the ear in which the receptor cells act not only as mechanoelectric, but also as electromechanical transducers. Knowledge of the innervation of mammalian inner-ear receptor cells by cochlear neurons has been unclear, partly because individual neurons could not be conveniently traced over their entire extent. The application of techniques that stain a few cells completely has clearly shown that cochlear neurons are segregated into two classes: the large majority of these neurons have large cell bodies and processes and innervate inner hair cells discretely, i.e., each neuron innervates one or two inner hair cells; a small fraction of the neurons have smaller cell bodies and processes and innervate outer hair cells diffusely, i.e., each neuron innervates many outer hair cells. Presumably, all of the recordings of fiber activity of the cochlear nerve have been obtained from the larger group; the function of the smaller neurons in the cochlea is unknown.

Research in the Sensory Communication Group (by Professor Louis Braida, Senior Scientist Nathaniel Durlach, Principal Scientist Steven Colburn, and Research Scientists William Rabinowitz, Charlotte Reed, and Pat Zurek) is focused on human perception and the senses of hearing and touch. In some projects, the goals are those of basic science; in others, the work is directed towards specific applications. Basic research on audition is directed towards the development of quantitative theoretical models for interpreting data (from both normal and impaired listeners) on such topics as pitch and loudness perception, binaural interaction, auditory nonlinearities, auditory short-term memory, and speech intelligibility. The principal applications being studied are concerned with the development of improved hearing aids, and more specifically, with signal-processing schemes to improve speech intelligibility for subjects with sensori-neural hearing impairments. Among the schemes being investigated are multiband amplitude compression

(for subjects with reduced dynamic range) and frequency lowering (for subjects with no useful hearing at high frequencies). Attempts are also being made to construct processing schemes that simulate the changes that occur when a speaker makes an exceptional effort to speak clearly. The Group's work on the sense of touch is focused on the use of the tactual sense as a substitute for hearing and on the development of tactual communication aids for the deaf and deaf-blind. Previous results have demonstrated that it is possible to understand continuous speech through the tactual sense (by placing a hand on the talker's face and monitoring the actions of the face associated with speech production) and thus indicate that the tactual sense is not fundamentally inadequate for the substitution. The main problems now concern the development of transformations from acoustic waveforms to patterns of tactual stimulation that will enable subjects to understand speech without physically contacting the speech source and without excessive training. These transformations must also be designed to permit accurate interpretation of general environmental sounds. Additional projects in the tactual area concern tactual music and tactual components of robotic and teleoperator systems.

Professor Victor Zue and his students are working on the problem of speech recognition by computer. The long range goal of their research is to provide a graceful person/computer interface through speech. The short term goals are the design and implementation of speech recognition systems with limited capabilities, but nevertheless with performance approaching that of humans. Some of the systems that they are developing include systems capable of recognizing continuous digit strings, and systems capable of recognizing isolated words from very large (20,000 words) vocabularies. Their approach explores the constraints on the allowable sound patterns imposed by the language, and the redundant information for various speech sounds contained in the signal. As part of their research effort, a Lisp machine-based speech research work station has been developed. The interactive software package, called SPIRE, is currently being used in many research laboratories around the country.

Professor Kenneth Stevens and his group continue to work on the simulation of LAFS for a small task, connected digits recognition. No results are available as yet because it is clear from preliminary simulations that the distance metric is still too sensitive to phonetically irrelevant spectral variability. Study of several new metrics is under way. A paper has been written, "The Problem of Variability in Speech Recognition and in Models of Speech Perception," in which several systems for recognizing speech are compared. It is concluded the techniques currently employed for isolated word recognition cannot overcome the inherent variability of speech, and a better understanding and characterization of the variability, both within speakers and across speakers will be required before significantly better recognition performance is achieved. Secondly, there are similarities between Harpy, LAFS, and the IBM systems. Taken together, the best ideas from each may lead to a practical continuous speech recognition system of considerable power.

Dr. Dennis Klatt reviewed the literature on auditory modeling, "Speech Processing Strategies Based on Auditory Models," in The Representation of Speech in the Peripheral Auditory System, R. Carlson and B. Granstrom, Eds., Elsevier/North-Holland Press, 1982, and concluded that current critical-band filtering models do not have sufficiently wide bandwidths at low frequencies to make the speech spectra of men, women, and children as similar and independent of fundamental frequency as possible. Auditory models that include mechanisms for processing inter-spike interval data are of interest because they may account for the importance of formant frequency locations in phonetic perception. However, these models depend on central mechanisms about which little is known, so that there is not very much that can be said about specific ways to implement a speech processing strategy patterned after human perception. Efforts to synthesize by rule several perceptually different male and female voices have resulted in a new implementation of the voicing source for the formant synthesizer. Three new control variables have been designed in order to have dynamic control over (1) the relative duration of the open phase of the glottal period, (2) the rounding of the waveform corner at the instant of glottal closure, and (3) the amount of turbulence noise generated during the open phase.

Professor Jonathan Allen and his students continue their work on custom integrated circuit design. The design problem consists of establishing an initial architecture, then designing each module of the resultant architecture. They have obtained the designs for the cells either from a library of previous designs, from a program that can generate a given type of cell, or from interactive use of a layout language. Their research has led to the development of layout programs that provide for the representation of cell types in terms of variables of the design that can be bound by the user. They also have developed both logic and layout optimization techniques for use with these programs. A high-performance signal processing chip is being designed using these techniques.

Professors William F. Schreiber, Donald E. Troxel, and their students are continuing research on computer-assisted image processing systems for graphic arts applications. A complete pre-press system for monochrome printing has been designed and installed at a large gravure plant, where it is used in daily production. It incorporates a page composition system and features engraving of printing cylinders directly from computer data. Production tests are being carried out on a color system. These sophisticated systems enable nontechnical operators to perform a wide variety of "photographic" operations by computer, resulting in substantial savings in time and materials while enhancing quality.

Professors Jeffrey H. Shapiro, Robert S. Kennedy, Robert H. Rediker, and their students worked to advance the understanding of a variety of optical and quasi-optical communication and radar systems. Work proceeded on the experiment to generate a light beam with reduced quantum noise; an experimental facility to measure the photon statistics of nanosecond duration optical pulses was assembled and tested. Successful experiments were performed on an external cavity semiconductor-diode laser which has an optical fiber within the cavity. These experiments are forerunners of a system which will coherently couple a large number of low power semiconductor lasers through fibers to produce a high average power semiconductor laser for space communications. Compact coherent laser radars have the potential for greatly improved angle, range, and velocity resolution relative to their microwave-radar counterparts. This program is aimed at obtaining a quantitative understanding of target-reflection and atmospheric-propagation effects on the performance of compact coherent laser radars through a combination of theory and experiments. Under a collaboration arrangement with the Optics Division of the MIT Lincoln Laboratory, the experimental portions of the research are being carried out on the compact CO_2-laser radars under development there. The central theme of their programs has been to advance the understanding of optical and quasi-optical communication and radar systems. Broadly speaking, this has entailed: developing system-analytic models for important optical channels; using these models to derive the fundamental limits on system performance; and identifying, and establishing the feasibility of, techniques and devices which can be used to approach these performance limits.

Professors Alan V. Oppenheim, Arthur B. Baggeroer, Bruce R. Musicus, Jae S. Lim, and graduate students have developed a number of new signal processing techniques and are applying them to speech, bloodflow, and image and geophysical data processing. The application areas which they deal with principally are speech, image and geophysical data processing. In addition to specific projects being carried out on campus, there is close interaction with Lincoln Laboratory and with the Woods Hole Oceanographic Institution. In the area of speech processing, they have over the past several years worked on the development of systems for bandwidth compression of speech, parametric modeling of speech using pole-zero models, time-scale modification of speech and enhancement of degraded speech. Recently they have obtained some important new results on time-scale modification of speech, growing out of a more general set of issues involving the estimation of a signal after its short-time Fourier transform has been modified. They are also exploring new techniques for speech enhancement using adaptive noise-cancelling when multiple microphones are available. There are a number of projects related to image processing that they are pursuing. They have developed a new image restoration system which is applicable to restoring images degraded by various different types of degradation. Their current work in this project involves development of new image restoration systems by exploiting additional available information such as the range map in infrared radar images. They are currently exploring the development of a very low bit rate (below 50 kbits/sec) video-conferencing system to model a human face, which is a regular feature in typical video-conferencing applications, with a set of parameters and then synthesize the image at the receiver from the coded parameters. This approach is analogous to modeling human speech for speech coding, which led to significant bit rate reduction without seriously degrading the speech intelligibility. The summers of 1983 and 1984 mark the beginning of a series of geophysical and acoustic experiments in the marginal ice zone of the Arctic. Two additional projects are the development of an algorithm for data processing to measure the acoustic reflection coefficient from the ocean bottom both for the deep water and shallow water cases. Out of this work has come a Hankel transform algorithm as well as a new method for generating synthetic data. Another interesting area of research is the connection between signal processing algorithms and computer architectures. Directions they are exploring include systematic methods for designing multi-processor arrays for signal processing, isolating signal processing primitives for hardware implementation, and searching for algorithms for multi-dimensional processing which exhibit a high degree of parallelism. A recent and growing emphasis in their group is the combination of signal processing and artificial intelligence techniques. Two projects under way attempt to exploit artificial intelligence concepts to develop a knowledge-based pitch detector and to explore knowledge-based signal processing in the context of signal enhancement.

JONATHAN ALLEN

Vice President, Resource Development

INTRODUCTION

During the past year, the third since the close of the M.I.T. Leadership Campaign, Resource Development staff members continued to work with the faculty and central administration on defining and updating the Institute's fund-raising goals. Last fall, in consultation with the deans, President Paul Gray and Provost Francis Low set priorities for projects with major program and capital needs. These included a number of ongoing efforts which required additional funding, such as the Microsystems Research and Education Program (VLSI), the arts and media technology facility, faculty endowment, and financial aid for both graduate and undergraduate students. Several new projects were undertaken: a campaign for fellowship and program support in the Department of Economics; a program of renovation of the undergraduate chemistry teaching laboratories; and a large-scale effort in computers for education, known as Project Athena. Athena will receive several million dollars in equipment support from two major computer companies, Digital and IBM, but a large need for program funds must be met.

The above are examples of the kinds of funding priorities for which Resource Development must be organized and structured. Funding strategies for several of these priorities are being pursued by "task forces." Each task force is led by a senior officer of the Institute, and includes one or more members of the MIT Corporation or Corporation Development Committee (CDC), as well as senior faculty interested in the particular project. A member of Resource Development is assigned as staff officer for each project. Back-up for all projects is provided by the Development Office and the Office of Communications/ Resource Development.

Thus far, task forces have been developed for: (1) VLSI; (2) the arts and media technology facility; (3) the Department of Economics fellowship and program support effort; and (4) the undergraduate chemistry laboratory renovations. Progress has been encouraging in all four areas.

The increasing needs of the Institute have placed an increased burden on the Resource Development staff to identify prospective donors and to decide which prospects should be approached for which of several worthy projects. Nelson C. Lees, director of resource development, has continued to provide effective leadership and assistance in this decision-making process. He also serves as secretary of the Council on Resources for the Institute and executive officer of the CDC.

PRIVATE SUPPORT

Total private support increased 21 percent over last year and, for the first time in MIT's history, crossed the $50 million mark. Corporate support from all sources (corporate liaison programs as well as corporate gifts) was at an all time high in both nominal and constant dollars. It is a sobering reflection on the effects of inflation, however, that the overall receipts of $56.2 million from corporations, foundations, and individuals, were less than that of ten prior years--primarily in the 1960s--when measured in constant (1975) dollars. Still, measured by any standards, 1983 was a strong year for private support. The total comprised $49.8 million in gifts, grants, and bequests, and $6.4 million in support through membership in corporate liaison programs (discussed elsewhere in this report). The total compares with $46.6 million in 1982, $47.5 million in 1981, $38.1 million in 1980, and $37.4 million in 1979. Payments on Leadership Campaign pledges had only a residual effect on cash flow in 1983.

Sources of gifts for fiscal year 1983 were: alumni, $14.6 million; non-alumni friends, $5.6 million; corporations, corporate foundations, and trade associations, $14.9 million; foundations and charitable trusts, $14.3 million; others, $0.3 million. Included in the totals for alumni and friends are gifts of $2.4 million made to the Maclaurin Pooled Income Fund and the William Barton Rogers Pooled Income Fund. The total income of $6.4 million for corporate liaison programs represented a 16 percent increase over the total for fiscal year 1982.

Donors designated expendable and endowed funds as follows: unrestricted, $6.7 million; departments, $18.9 million; faculty salaries, $6.4 million; graduate scholarships and fellowships, $3.0 million; undergraduate grants, awards, and loan funds, $2.8 million; building construction funds, $7.0 million; other funds $5.0 million.

Included in the totals above was support for six new professorships: one for senior faculty, two for associate professors, and three for assistant professors.

CORPORATION DEVELOPMENT COMMITTEE

Members of the Corporation Development Committee (CDC) supported a variety of priority funding efforts during the year, including service as volunteers with Leadership Gifts and the National Business Committee, and on task forces for the renovation of the undergraduate chemistry laboratories and for fellowship support in economics.

The annual meeting of the CDC was held on November 19, with 77 members attending and with Howard W. Johnson presiding for the last time before stepping down from the position of chairman of the MIT Corporation. During the day, senior officers and deans addressed problems of international technology transfer, secondary school education, and federal support of basic research; the budget; challenges and initiatives in the Schools of Engineering and Science; the need for increased private support, and the task force approach to fund raising.

In an innovative noontime program, members were assigned to small groups and visited seven on-campus research sites. At these locations, they were served lunch and participated in discussions and tours of laboratories and facilities. The 1983 Dalton Bowl was presented to Floyd A. Lyon, Class of 1942, in recognition of his years of outstanding work for MIT.

We note with deep regret the passing of two honorary CDC members: Marion W. Boyer, Class of 1925, and Alfred E. Perlman, Class of 1923.

DEVELOPMENT OFFICE

Priorities within the Development Office continued to be the computerization and improvement of management systems for the Institute's central development data bank. This work, coordinated by G. Rodger Crowe, associate director of the Development Office, provided more efficient service to senior officers, faculty, and development staff in approaching major prospects in the private sector. Current information systems were refined for more precise monitoring of gift streams, pledge payments, and the status of fund-raising projects at various stages.

The primary objectives of the Development Office remained the identification and evaluation of prospects, the integration of clearances and proposal submissions, and the recommending of approach strategies. Major assignments carried over from the previous year included support of the VLSI facility, arts and media technology, the health sciences, and financial aid for both undergraduate and graduate students. New initiatives included staff support for Project Athena, renovation of undergraduate chemistry laboratories, the engineering design center, and fellowships for the Department of Economics.

Since 1979 the Institute's program of foundation relations, both private and corporate, has been conducted by Vincent C. DeBaun, director of the Development Office, with the support of the associate and assistant directors. A wide range of cultivation efforts matured in the past year with significant new funding provided for robotics research, cancer research, computer music, retention of young faculty in engineering, and fellowships for graduate students.

HEALTH SCIENCES

Several new health sciences funding sources made grants to support faculty, graduate fellowships, research, and curriculum development during the past year. Neurosciences, toxicology, and biomedical engineering programs were funded by foundation and corporate grants, as well as by gifts from individuals. Major program support was received for the Whitaker College, the Center for Cancer Research, and the Newman Laboratory for Biomechanics and Human Rehabilitation.

Barbara Gunderson Stowe, the Institute's development officer for the health sciences, worked with faculty, administration, and other resource development staff in seeking support and identifying future prospects. Particularly involved was Kenneth A. Smith, vice president for research and associate provost. Provost Smith is the senior officer responsible for the Institute's health-related research programs. Dean Emeritus Irwin W. Sizer, former head of the Department of Biology and a noted biochemist, worked closely with Ms. Stowe as consultant to Resource Development.

COMMUNICATIONS

The Office of Communications, under the direction of Deborah J. Cohen, produced proposals and publications in support of funding efforts throughout MIT. Among the publications issued were: a case statement for the Department of Economics; a revised booklet on endowed professorships at MIT; a revised brochure for MIT Sustaining Fellows; information on the Maclaurin and Compton pooled income funds; and fund-raising materials for other departments, laboratories, and centers.

Proposals and statements were written to seek funding for: professorships in the health sciences and in the various departments and schools; a number of interdisciplinary and departmental centers, laboratories

and programs; major efforts such as VLSI, arts and media technology, Project Athena, and the MIT-Technological University of Berlin Cooperative Research Program; research projects; equipment and renovation; discretionary funds; and special conferences. Projects were carried out in consultation with senior officers and faculty members across the Institute.

Donor relations activities included providing research and assistance in preparing several thousand gift acknowledgments, and reports to donors on uses of funds. Among new efforts in the area of donor relations were development of a computerized system for gift stewardship and a program of campus visits, to begin in the fall.

During the year, senior writer Katharine S.C. Jones took an extended leave of absence from MIT. She was replaced by Patricia E. Harrison, formerly of MIT's Center for Policy Alternatives, who joined the staff as assistant writer. Several promotions occurred: Martha L. Bertrand and Ellen N. Hoffman became assistant directors of communications, and Sarah M. Abrams became associate writer.

PLANNED GIVING

Planned giving is an important part of the development program at all universities, including MIT. During the past year, planned gifts accounted for a substantial portion of support from individuals. These gifts were arranged through the efforts of D. Hugh Darden and Thomas R. Henneberry, director and associate director, respectively, of the Office of Planned Giving and Legal Affairs. All efforts were in closest coordination with senior officers, faculty, and staff, including Alumni Association and Fund staffs. The Maclaurin Pooled Income Fund/A Special Announcement was mailed to members of classes graduated 35 years and over with a remarkably good response. A total of 10 planned giving meetings were held at various locations in connection with reunion gift efforts. Arrangements for two new pooled income funds were completed. Techfund, a growth fund, opened on June 1, 1983, and received its first contribution shortly thereafter. The Karl T. Compton Pooled Income Fund was established and will open on July 1, 1983. There was a significant increase in gifts of equipment during the year.

Summary of Activity

	Donors	Dollars
Separately invested unitrusts	2	$1,055,288
William Barton Rogers Pooled Income Fund	4	440,897
The Maclaurin Pooled Income Fund	59	2,028,052
Techfund	1	97,569
Receipts from bequests, testamentary, and other trust arragements	83	3,753,286
TOTAL	149	$7,375,092

During the year, 34 estates and outside trusts were closed and fully distributed (amount included in table above). As of June 30, 1983, 1,242 notifications of plans for future gifts, including irrevocable trusts in which the Institute has a vested future interest, were on record with the Institute. Irrevocable trusts totaled 375 (see table below).

	Number	Dollars Current Market Value
Trusts held outside MIT	144	$29,733,910
Trusts held by MIT	231	13,250,352
TOTAL	375	$42,984,262

During the year, four trust funds held by the Institute totaling $45,903 were closed and transferred over free of trust for Institute purposes. On April 1, Thomas R. Henneberry joined the Treasurer's Office as insurance and legal affairs officer. He will continue to provide assistance in the area of planned gifts. This is the final report of this activity within Resource Development. On July 1, D. Hugh Darden becomes assistant treasurer, Planned Gifts and Legal Affairs. These changes have been made to provide increased effort in planned giving, but without an increased budget.

LEADERSHIP GIFTS

The Leadership Gifts roster includes approximately 1,400 individuals who have been identified as potential donors of major gifts. This year staff members have placed added emphasis on refining this list and seeking the names of additional prospects--a process which must be handled vigorously and systematically in 1983-84.

James L. Bidigare, Jr. was engaged as a consultant to establish an EDP prospect monitoring system. The system will be capable of accessing any pertinent data, including alumni giving records, from the Alumni Association's database. The system should be in operation late in the summer of 1983.

Since the completion of the Leadership Campaign, volunteers have continued to provide great assistance in introducing MIT development staffers to potential donors. An increasing share of actual solicitation visits has been performed by Leadership, Planned Giving, and Sustaining Fellows staff members, either singly or jointly with volunteers. The same trend has been reported by the several universities whose fund-raising we follow most closely. Two factors contribute to this trend: the obvious loss of volunteer momentum following a successful campaign and the increasingly sophisticated financial arrangements being utilized for making major gifts from capital.

The Leadership Gifts staff of four, including its director, Donald P. Severance, has worked closely with the Alumni Fund in identifying and soliciting major prospects for the class reunion gift programs--introducing for the first time an unusually successful sixtieth reunion class gift. Staff members have also collaborated effectively with the Office of Planned Giving and Legal Affairs in conducting special meetings with alumni and spouses interested in life income plans and other creative forms of making capital contributions.

Last fall, Edith E. Nelson was appointed associate director of the Leadership Gifts program. Besides continuing to discharge the district director's responsibilities for her regional areas, her new responsibilities include coordination of operations with the Sustaining Fellows program (which became associated with Leadership Gifts during the year); with the Alumni Fund's programs for class reunion gifts and personal solicitation; and assuming a prominent role in developing the new EDP system.

This June the office of E. Barbara Lewis, executive officer for the Sustaining Fellows program, moved to adjacent offices on the sixth floor of Building 24, in order to achieve closer coordination with the Leadership Gifts program.

MIT SUSTAINING FELLOWS

In its fourth year, the MIT Sustaining Fellows continued its programs for recognition, involvement, and cultivation of major donors. The Sustaining Fellows program now has approximately 640 members, two-thirds of whom are life members. Each year, resources from the unrestricted Sustaining Fellows fund are allocated by the president for support of a specific project. This year President Gray designated $300,000 for the rebuilding and landscaping of a portion of "Amherst Alley" between McCormick Hall and Burton House. Work will take place in the summer of 1984. During 1981-83, the fund provided for the acquisition of an automated circulation system for the MIT Libraries.

As part of the ongoing effort to more closely involve Sustaining Fellows with MIT, members continued to receive special invitations to all of the Industrial Liaison Program (ILP) symposia and seminars. More than 50 Sustaining Fellows attended a special two-day meeting for senior executives sponsored by the ILP this past June. In March, F. Richard Meyer III, Class of 1942, hosted a dinner for President Gray and the Sustaining Fellows in the Chicago area.

On May 16, 1983, the second major event for the Sustaining Fellows was held in Cambridge, with about 175 attendees. Professor David Baltimore introduced Professor Robert Weinberg, who spoke on his current research and the latest developments in the study of cancer.

Corporation member Breene M. Kerr, Class of 1951, continued to serve as the chairman of the MIT Sustaining Fellows, and Professor Elias P. Gyftopoulos continued as faculty chairman. Howard W. Johnson, chairman of the MIT Corporation, and President Gray remained honorary chairmen. David Saxon will become honorary chairman of the program when he assumes the chairmanship of the MIT Corporation on July 1. E. Barbara Lewis continues to serve as the executive officer of the MIT Sustaining Fellows program.

CORPORATE RELATIONS

The new chairman of the National Business Committee (NBC), Robert L. Mitchell, Class of 1947 (Graduate School) and vice chairman of Celanese Corporation, began his tenure on July 1, 1982. His contacts with NBC members stressed the need to keep at the job of raising corporate funds, despite the difficult economic situation. His encouragement resulted in 30 visits to corporations and an additional 7 visits by corporate representatives to MIT. Several additional proposals were made on the basis of introductions to companies by NBC members.

As the NBC activity matures, the identification and cultivation of alumni who are able to arrange high-level corporate introductions must be intensified. During the past year, 36 such alumni were visited. Many of them have already accepted assignments and produced visits. Several of these are alumni who have not previously worked on behalf of MIT, and who hold important positions in the business community. Through their work with the NBC, many will be encouraged to serve the Institute in other ways in the future.

NBC members and associates are now assigned 132 companies. A substantial number of these will be visited in the coming year, particularly if the current upward trend in the economy continues. Good progress was made toward reaching new types of companies. For example, working closely with the Sloan School Resource Development Committee, visits were made to nearly all the leading accounting firms. The potential from this activity appears promising. Plans are also under way to approach insurance, financial, and other nonindustrial concerns.

The NBC's staff support continued to be directed by Robert Hagopian. Effective assistance came from other Resource Development staff members, as well as many members of the faculty. We are particularly grateful to the Leadership Gifts staff for assistance in identifying NBC associates, and to the Industrial Liaison Program staff for assistance with companies solicited for ILP membership.

Howard Kehrl, Class of 1960 (S.M. Sloan) and vice chairman of General Motors, resigned his membership on the committee effective June 30, but remains an active supporter of MIT.

During the year, Jacquelyn Findlay, associate director, left the Institute and assumed the position of development officer for a biomedical research agency.

INDUSTRIAL LIAISON

Fiscal Year 1983 revenue was $6,403,209, a 15.6 percent increase over last year. The number of companies increased from 281 to 287, with 47 in Europe, 43 in Japan, and 4 in South America.

During the past year, interaction between MIT and ILP members continued to grow. The ILP hosted over 1,400 visits for 2,500 visitors, involving 3,000 meetings with faculty and staff. In addition to 400 liaison officer visits to member companies, 550 visits were made by faculty members. More than 450 telephone conferences were arranged between member company personnel and MIT faculty.

Sixteen symposia presented by MIT faculty members for ILP member companies in the US had a total attendance of 3,615, a 67 percent increase over Fiscal Year 1982. Five seminars and three courses were presented in Europe by 10 MIT faculty and staff with a total attendance of 260. In Japan, 14 seminars were presented by 14 MIT faculty members with a total attendance of 420. In addition, a symposium for senior executives, "Global Technological Change: A Strategic Assessment," which took place June 21-23, was attended by more than 400 persons.

A special symposium, "Effective Business Management: Lessons from Japan," was jointly sponsored by the Industrial Liaison Program and the Sloan School of Management. The meeting was attended by approximately 200 US and Japanese executives.

Two intensive laboratory courses in VLSI design were held at MIT under the auspices of the ILP: "VLSI Design" (June 6-17) and "Advanced VLSI Design" (June 20-July 1), with a total attendance of 79.

The Publications Office mailed over 50,000 publications to members companies in response to 13,000 requests, a 10 percent increase over Fiscal Year 1982.

On April 22, the ILP moved into renovated offices on the fourth and fifth floors of Building E38. This move brought together staff who had been dispersed throughout the campus.

Several promotions occurred among the staff during the past year: John T. Preston to associate director; Frederick P. Gross and Laura E. Scott-Stout to assistant directors; and W. Scott Johnsen to manager of computer operations. Carmen R. Besterman was appointed manager of Latin American operations, and

Carmela R. Sciandra was appointed programmer/analyst. Sandra S. Sozanski resigned as conference coordinator to relocate in California; and Clyde E. Kelley resigned to become director, industry/university programs, MicroElectronics Center of North Carolina.

In addition, this fiscal year completed the tenure of James D. Bruce as director of Industrial Liaison. On July 1, Professor Bruce becomes MIT's director of information systems. He will be succeeded by James M. Utterback, professor of management.

CONCLUSION

This report would not be complete without special mention of Howard Johnson's outstanding leadership and service as chairman of the MIT Corporation. As chairman, Mr. Johnson has been closely connected with fund-raising for major needs throughout the Institute. We owe him a great debt, for he has done much to insure MIT's financial and intellectual future.

Thanks for a job well done go to James Bruce, director of Industrial Liaison, as he moves on to assume greater responsibilities within MIT. We will miss him, and wish him well in his new post.

Finally, I want to acknowledge the extra efforts made by all the members of Resource Development in achieving this year's outstanding results with a reduced staff and reduced budget. To all go the sincere thanks of the undersigned.

SAMUEL A. GOLDBLITH

Lincoln Laboratory

Lincoln Laboratory is operated by MIT as a Federal Contract Research Center for performing research and development in advanced electronics. During the past year, agencies of the Department of Defense (DOD) -- the Air Force, Army, Navy, and the Defense Advanced Research Projects Agency (DARPA) -- supplied 97 percent of the Laboratory's budgetary support. The Federal Aviation Administration provided most of the non-DOD support. The size of the Laboratory has increased about 5 percent to accommodate program changes. In fiscal year 1983 the operating budget was $235 million, supporting the efforts of 814 professional staff, 76 percent of whom hold advanced degrees.

Several administrative changes at the Laboratory Steering Committee level occurred during the year. Dr. John V. Evans resigned as Assistant Director to accept a post at the COMSAT Corporation. Mr. Stephen H. Dodd, Jr., retired as Head of the Radar Measurements Division and Mr. William Z. Lemnios, Associate Head of the Division, was promoted to Division Head. Dr. Louis C. Marquet, Associate Head of the Optics Division, was given a leave of absence to accept a post at the Defense Advanced Research Projects Agency, and was succeeded by Dr. Herbert Kleiman.

Technical work areas at the Laboratory include radar and optical sensors, measurements, and systems; satellite communications; signal design and processing; lasers; solid-state devices; digital technology, circuitry, and data systems; tactical and strategic systems and countermeasures; and air traffic control systems. Unclassified highlights of several accomplishments during the past year are summarized below.

TECHNICAL SUPPORT OF NAVAL ANTI-AIRCRAFT WARFARE SYSTEMS

The U.S. Navy has recently completed a six-month Outer Air Battle Study to determine what directions the Navy should pursue in order to have a capable outer air defense for fleet units in the 1990s. Lincoln participation in this Study provided chairmanship of the Systems Panel, some presentations of the results of the Study, and technical support in various areas. The Study has been briefed to the Chief of Naval Operations and to the Secretary of the Navy, and has been very well received.

CUSTOM DIGITAL INTEGRATED CIRCUITS

Using computer-aided design (CAD) tools developed at Lincoln and on campus at MIT and other universities, staff members at Lincoln without previous integrated circuit experience have successfully designed custom integrated circuits for functions which were not available as commercial parts. The devices, as designed, were fabricated by the DARPA IC fabrication ("Foundry") service and were demonstrated in experimental communication equipment. Circuits with more extensive specifications are now being designed for a radar signal processor.

An advanced silicon compiler program has been developed for generating layouts for NMOS circuits from a concise functional specification. This approach to CAD greatly reduces the effort required to design integrated circuits and facilitates exploration by the designer of space-time tradeoffs. A custom automatic gain control circuit for a speech vocoder was successful on the first try and signal processing chips have been designed in four days as compared to the months required using conventional techniques. A second program, the Lincoln Boolean Synthesizer, has successfully demonstrated the ability to generate a CMOS layout from a Boolean equation specification.

Under the Restructurable Very Large Scale Integration project a laser restructuring technique has been demonstrated for cutting lines and making connections on a wafer. The overall goal is to develop techniques for constructing whole-wafer systems which will have improved performance and reduced size and weight compared to systems built from multiple chips in separate packages. The restructuring is used to wire around defective portions to increase process yield and to customize the circuit after fabrication. New CAD capabilities required for this higher level of integration have been developed. A wafer-scale system for performing digital integration was demonstrated this year and systems with up to one million transistors, including provision for 200 percent redundancy, are being fabricated.

IDENTIFICATION OF FRIEND OR FOE (IFF)

The accurate identification of targets seen merely as "blips" on a radar scope has been an important military problem since World War II. For the past four years, the Laboratory has been concerned with the development of a new, cooperative, question-and-answer IFF system that will meet the needs of NATO as well as the U.S. in the post-1985 time period. The new system should have sufficient security to prevent an enemy from generating spurious questions and answers that appear authentic, and also have a high degree of jamming resistance.

Critical issues in developing this system have centered on the choice of its operating frequency, the design of signals which can be reliably processed in compact, affordable equipment, and the effects of electronic countermeasures and various propagation phenomena, especially multipath, on these signals.

Analytic estimates were made of the communication reliability of several candidate IFF signals in the presence of jamming, self-interference, and multipath propagation; the electromagnetic interference caused by these signals was also estimated. Two signal processor test beds, one operating at L-band and one at S-band, were developed to verify experimentally the reliability that can be achieved with these IFF signals. Measurements were made to characterize propagation phenomena in the pertinent geometries and over typical terrain types.

During the past year the U.S. Air Force, Army, and Navy have jointly adopted a specific signal design based in large part on the Laboratory's recommendations; this design is now being considered for NATO-wide adoption.

SPACE RADAR TECHNOLOGY

A multi-year program has been initiated under Air Force sponsorship to define, develop, and test technology leading to a new space-based radar concept for worldwide air and surface surveillance. There has been considerable interest in a space-based radar capability for a number of years. However, concepts previously proposed did not appear to offer the desired capability within reasonable limits of technical risk and costs. These earlier concepts were generally based on radar technology using pulsed doppler waveforms to resolve targets in the heavy surface clutter seen from space.

The space-based radar concept proposed by Lincoln Laboratory uses a displaced phase center antenna to cancel surface clutter and allow the detection of moving targets. This concept was employed in an airborne battlefield surveillance radar developed at the Laboratory in the mid-1970s. Cancellation of the ground clutter allows the radar to operate at lower altitude with a smaller aperture and at a lower frequency than possible with the more traditional pulsed doppler approach. The radar will use on-board signal processing for cancellation of main beam clutter and to effect adaptive nulling of interfering signals. Target detection reports will be generated on board for transmission to the ground via satellite relay at low data rates.

Initially, the program has emphasized concept validation through extensive mathematical analyses, computer simulation, and component testing. Component design will lead to antenna and signal processor breadboard tests. Clutter cancellation, interference rejection, and target detection performance will be measured in a ground test facility. In parallel, technology for space-compatible transceiver modules and digital components for the on-board signal processor will be developed and tested. Improvements in satellite power storage through advanced batteries and high performance flywheels will be analyzed and tested. In the event of a decision to deploy a space-based radar system, this program would conclude by the transfer of technology to industry and by providing assistance to the Air Force in the procurement of the system.

SATELLITE COMMUNICATIONS

The satellite communications program of the Laboratory has for several years addressed the problem of providing anti-jam communication service at acceptable cost to a large number of mobile and transportable users. To accomplish these objectives, the Laboratory has devised a system concept which incorporates a number of state-of-the-art techniques. This system operates at millimeter wavelengths and employs band-spread modulation for anti-jam characteristics. The Laboratory's technology program has focused on the development of critical components necessary to realize this system, including adaptive and agile-beam satellite antennas, on-board signal processing, and solid-state millimeter-wavelength components.

Recently, the Department of Defense committed itself to a new satellite communication system called MILSTAR with characteristics close to the Laboratory's system concept and whose realization will be based largely on technology developed by the Laboratory. To facilitate the evolution of MILSTAR, the Laboratory is designing and building two flight packages to be placed in orbit in the mid-1980s. These packages support the test and evaluation of earth terminals being developed by the Services and will provide an interim partial communications capability pending the launch of the full capability MILSTAR satellites being produced by industry.

A second MILSTAR-related task being addressed by the Laboratory is the design and construction of the advanced development model of the new Army millimeter-wavelength ground terminal. This small, transportable terminal is rugged, simple to operate, and modest in cost. The advanced development model terminal will serve as a baseline for the design and production of operational MILSTAR terminals.

OPTICAL CROSS-LINKS USING HETERODYNE DETECTION

Space systems of the future will require small, efficient, high capacity satellite-to-satellite communications links. We are developing such a link operating at optical wavelengths and utilizing heterodyne detection. The transmit laser and the local oscillator at the receiver utilize a single-spatial-mode, single-frequency GaAlAs CW laser. Frequency modulation of the transmit laser diode is accomplished by direct current injection. Silicon PIN photodetectors are used in a novel 2-detector heterodyne receiver yielding receiver sensitivities close to the quantum-limit. This receiver is 13-20 dB more sensitive than conventional direct detection receivers, thus allowing the use of smaller antennas and lower power levels.

SOLAR PHOTOVOLTAIC PROGRAM

In late 1982 Lincoln Laboratory concluded a six-year program directed toward the development and evaluation of terrestrial photovoltaic (PV) power systems. During this period, 33 systems containing approximately 300 kilowatts of generating capacity were fielded in various locations ranging from New England to Hawaii. During the past year, the MIT Energy Laboratory assumed responsibility for Lincoln's residential PV development in the Northeast. New Mexico State University undertook analogous responsibility for Lincoln's residential work in the Southwest. In addition, a new residential PV activity, centered in the Southeast and administered by Sandia National Laboratories, was initiated this year. This provides a total of three Residential Experiment Stations, which is in accordance with the plan Lincoln Laboratory prepared for the Department of Energy three years ago.

The program has shown, during the past three years, that residential PV systems are feasible and reliable, although cost remains a major problem. A further cost reduction of approximately a factor of five is required for these systems to be competitive with electricity supplied from conventional utility sources. A large fraction (typically 50 to 75 percent) of the home's electricity demand over the year can be provided by such systems. Integration into the house structure was found to be neither difficult technically nor deleterious to the overall appearance of the residence. Integration with the utility appears to be straightforward, using a utility-interactive DC-to-AC inverter which sends excess PV-generated electricity back into the utility lines for use elsewhere. On cloudy days and at night, the house's electrical needs are supplied by the utility.

WALTER E. MORROW, JR.

Secretary of the Institute and Secretary of the Corporation

The Secretary of the Corporation serves as the Corporation's annually elected Recording Officer and joint signatory with the President in the awarding of the academic degrees of the Institute. The officers and committees of the Corporation rely upon the Secretary of the Institute to provide a range of support for the operation of the Corporation and its committees. This report summarizes the work of the Institute's governing body.

CORPORATION MEMBERSHIP

At the year's end the record total of 101 Members of the Corporation included 75 Active Members, 25 Life Members Emeriti, and one Member-Elect due to assume office at the October 7, 1983 Annual Meeting of the Corporation. There were 25 individuals whose membership status changed during 1982-83 in a year of very high activity for the Membership Committee.

At its December 3, 1982 Meeting, the Corporation unanimously elected David S. Saxon, Class of 1941, retiring President of the University of California, a Life Member, effective immediately, and Chairman of the Corporation, effective July 1, 1983. A Search Committee, chaired by Carl M. Mueller, which included Angus N. MacDonald and Emily V. Wade, reported on its year-long deliberations to recommend a successor to Howard W. Johnson. Dr. Saxon served with distinction as a term Member of the Corporation for five years, 1978-82. Before beginning his remarkable career as a member of the physics faculty at UCLA, which led to his rise to one of the nation's most respected university heads, Dr. Saxon earned his SB and PhD degrees in physics at MIT. His return to the Institute as our Sixth Chairman has been widely acclaimed by MIT alumni and friends around the globe. His fundamental concern for the quality of education and his lifetime of experience in building the quality of the University of California and in speaking out on issues of basic concern to higher education make him an outstanding choice for his new responsibilities at MIT.

At its May 27, 1983 Meeting, the Corporation elected the following Members to Life Membership, effective July 1, 1983: Ellmore C. Patterson, former Chairman of the Board, Morgan Guaranty Trust Company; and Edward O. Vetter, Class of 1942, President, Edward O. Vetter & Associates, Inc., both of whom had served two previous, consecutive five-year terms. Also elected to Life Membership was Howard W. Johnson, retiring Chairman of the Corporation, who was elected Honorary Chairman at the same time.

At its May 27, 1983 Meeting, the Corporation further elected the following Members to five-year terms, effective July 1, 1983: Robert A. Charpie, President, Cabot Corporation; Herbert H. Dow, Class of 1952, Executive Department, Dow Chemical Company; Joseph G. Gavin, Jr., Class of 1941, President, Grumman Aerospace Corporation; W. H. Krome George, Class of 1940, Chairman of the Executive Committee, Aluminum Company of America; Floyd A. Lyon, Class of 1942, Chairman of the Board and Chief Executive Officer, Halm Industries Company, Inc., Glen Head, New York; Denman K. McNear, Class of 1948, Chairman and Chief Executive Officer, Southern Pacific Transportation Company; and Mary Frances Wagley, Class of 1947, Executive Director, Episcopal Social Ministries of the Diocese of Maryland, Inc. At the same Meeting, Rhonda E. Peck, Class of 1982, a recent graduate of the Sloan School of Management, was elected a Member for a five-year term, effective October 7, 1983.

In addition, Robert W. Mann, Class of 1950, Whitaker Professor of Biomedical Engineering in the Department of Mechanical Engineering, became a Guest of the Corporation Meeting by virtue of his selection as the 1983-84 President of the Alumni Association. In that position, he succeeds Denman K. McNear, effective July 1, 1983. Dr. Mann is the fifth member of the MIT faculty to be elected President of the Alumni Association since its founding in 1875. Under the Bylaws of the Corporation, he becomes a Guest but not a Member of the Corporation in his new role.

Our Life Members, Kenneth J. Germeshausen, Class of 1931, Founder and Past President and Chairman, EG&G, Inc.; Gregory Smith, Class of 1930, Former President and General Manager, Eastman Gelatine Company; Joseph J. Snyder, Class of 1944, Treasurer Emeritus; and John J. Wilson, Class of 1929, Honorary Secretary of the Corporation, transferred to Life Member Emeritus during the year. Together these four Life Members have served on the Corporation for a total of close to a century. All of them remain actively involved in the affairs of the Corporation. Two of them, Messrs. Smith and Snyder, maintain offices at MIT.

The Corporation was saddened by the death of Helen F. Whitaker, Life Member Emerita, Trustee of the Whitaker Health Sciences Fund, in Naples, Florida, on September 13, 1982. Mrs. Whitaker became a term Member of the Corporation in 1976. In 1979 she and Ida M. Green became the first women to be elected Life Members of the Corporation. She became a Life Member Emerita in March 1982. Several officers of the Corporation attended a memorial service for Mrs. Whitaker in Harrisburgh, Pennsylvania, at which Chairman Johnson spoke.

In her passing the nation has lost an extraordinary advocate of basic research and advanced education in human health and an indomitable human spirit. We at MIT have lost a staunch friend and towering benefactor who participated in the affairs of the Corporation for more than 25 years.

Mrs. Whitaker's association with the Institute began several years prior to her election to the MIT Corporation as the wife of Uncas A. Whitaker, distinguished MIT alumnus and founder of AMP Incorporated. During their 31-year marriage, she shared equally in the events and accomplishments of her husband's brilliant career as an industrialist in his philanthropic endeavors.

The Whitakers stand among MIT's all-time, major benefactors. They were early advocates of the life sciences and the Harvard-MIT Division of Health Sciences and Technology. Before that, their contributions made possible the construction in 1965 of the Uncas A. and Helen F. Whitaker Building for the Life Sciences. This building houses elements of MIT's Department of Biology and Department of Nutrition and Food Science. They also established the Whitaker Professorship in Biomedical Engineering held by Professor Robert W. Mann of the Department of Mechanical Engineering. They instituted the Whitaker Health Sciences Fund in 1974 to further basic research in the health sciences at MIT and other Boston area institutions; and they provided major support for the biomedical engineering laboratories in the Fairchild Building housing the Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics. They were also leaders in the advocacy which preceded the development of the MIT Health Plan.

For more than six years, after her husband's death in 1975, Mrs. Whitaker played a leading role in the evolution, planning and construction of the buildings for the Whitaker College of Health Sciences, Technology, and Management and the Medical Department Health Services Center. She spoke at the Groundbreaking Ceremony on June 4, 1979. Those of us who were present on March 5, 1982 for the dedication of this grand complex were privileged to share her joy that this magnificent task had been accomplished.

Whitaker College is the first division of MIT to be called a college. In conjunction with the College, Mrs. Whitaker established the Uncas and Helen Whitaker Professorship of Health Sciences, held by Professor Christopher T. Walsh of the Department of Chemistry. She attended the first meeting of the Visiting Committee of Whitaker College in December 1981. She is sorely missed.

Expiration of term membership has cost the Corporation the formal services of Paul Hotte, Class of 1942, Consultant in Corporate Development; Brian G. R. Hughes, Class of 1977, Senior Vice President, United States Aviation Underwriters, Incorporated; I. M. Pei, Class of 1940, Founder and Principal, I. M. Pei & Partners; Stanley M. Proctor, Class of 1943, Founder and President, Stanley M. Proctor Company; and Emily L. Wick, Class of 1951, Assistant to the President for Long Range Planning and Professor of Chemistry, Mt. Holyoke College. These retiring Corporation Members continue their association with the Corporation in many ways as members of various alumni, Corporation, and Institute committees.

As part of his succession to the Office of Chairman of the Corporation, David S. Saxon resigned his Life Membership on the Corporation, effective July 1, 1983. Effective January 6, 1983, Michael S. Dukakis became Governor of the Commonwealth of Massachusetts and an ex-officio Member of the Corporation. We welcome Governor Dukakis back to the Institute's governing body. He succeeded Governor Edward S. King who served as a Representative of the Commonwealth on the Corporation for four years, 1979-83. Governor Dukakis' return to the Corporation is only the third time in the Institute's 122-year history that a chief executive of the Commonwealth has been returned to office by the electorate after being out of office.

Under the Bylaws of the Boston Museum of Fine Arts (MFA), the President of MIT annually appoints a representative from MIT to serve on the MFA Board of Trustees. During the past year, the Institute's representative has been Professor Phyllis A. Wallace of the Alfred P. Sloan School of Management. Several Corporation Members also serve as MFA Trustees. Dr. Johnson continued his service as Chairman of the Overseers of the Museum of Fine Arts.

CORPORATION JOINT ADVISORY COMMITTEE ON INSTITUTE-WIDE AFFAIRS

The Corporation Joint Advisory Committee on Institute-Wide Affairs (CJAC) devoted the year to a study of the cluster of issues surrounding the Institute's policies on student financial aid. An innovation in planning CJAC's agenda was introduced by Claude W. Brenner, Chairman of CJAC. By prior arrangement, the ex-officio members of CJAC met with President Gray on October 13, 1982 to fix CJAC's agenda for the year. The President noted the growing difficulty in the Institute's ability to draw increasingly upon unrestricted funds to support the needs of students under MIT's policies of need blind admissions for undergraduates and our commitment to meet the full need of our students. It was agreed that CJAC would focus on problems of undergraduate student financial aid in parallel with two other MIT committees working on the same cluster of issues. CJAC subsequently met on six occasions during the year and Mr. Brenner made an interim report to the Corporation at its March 4, 1983 Meeting.

I wish to acknowledge the brilliant leadership of our Corporation Member, Claude W. Brenner, who served as Chairman throughout the year, and the voluntary assistance given to CJAC by Iris E. Lazarus of this office, who also served as voluntary Secretary of CJAC. This study of undergraduate student financial aid is continuing during 1983-84.

DEDICATIONS AND SPECIAL FUNCTIONS

The Corporation continued to carry prime responsibility for dedications of major facilities and many special functions. Notable ceremonies this year included an afternoon dedication of James B. Fisk House and George W. Thorn House in the New West Campus Houses on October 2, 1982. The Fisk and Thorn families were guests of honor at a reception and picnic luncheon at the Houses. This year's ceremonies also included a morning dedication on December 2, 1982 of the John R. Freeman Lobby at the second floor junction of Buildings One and Five. A luncheon in honor of members of the Freeman family followed the speaking program. The dedication was held in conjunction with the regular meeting of the Civil Engineering Visiting Committee. Other dedications included the naming of the fourth floor corridor museum outside the Harold E. Edgerton Stroboscopy Laboratory as the Harold E. Edgerton Strobe Alley on April 6, 1983 on the gala occasion of Dr. Edgerton's eightieth birthday; the dedication of the Edward Pennell Brooks Center and the Carol Wright Brooks Garden at the MIT Endicott House in Dedham, Massachusetts, in honor of our former Corporation Member, Dean Emeritus Edward P. Brooks, and the late Carol Wright Brooks on the afternoon of Commencement Day, May 27, 1983; and the dedication of Ida Flansburgh Green Hall, MIT's first residence hall for graduate women students, in honor of our Life Member Emerita, Ida M. Green, on the afternoon of Technology Day, June 10, 1983. I wish to recognize the selfless dedication of Mary L. Morrissey, Director of the Information Center, in the planning and execution of major facilities dedications. She is a joy and an indefatigable ally.

On the evening preceding the March 4 Meeting of the Corporation, the Corporation held a black tie dinner at the MIT Faculty Club in honor of retiring Chairman Howard W. Johnson and Mrs. Johnson. Carl M. Mueller served as master of ceremonies. Dinner speakers included President Paul E. Gray, who spoke of shared experiences at MIT and who presented the Chairman with an historic, pre-Civil War American Flag; President Emeritus Jerome B. Wiesner, who annotated video film strips of faculty meetings during the period of campus unrest and Dr. Johnson's presidency, and who spoke of his experience working with the Chairman; Frank Press, who spoke of Dr. Johnson's contributions to national policy-making in the areas of higher education, basic research, and industrial productivity; I. M. Pei, who spoke of Dr. Johnson's contributions to the arts at MIT, in the Boston area through his distinguished leadership of the Boston Museum of Fine Arts, and nationally through his advocacy of the arts to Congress and the Executive Branch of Government; and Priscilla K. Gray, who presented an original poem and a memento from the President's House to Elizabeth W. Johnson. This salute to the Johnsons was attended by some two hundred present and former Members of the Corporation and the present and former Academic Council and their spouses. The following day, President and Mrs. Gray held an afternoon reception in honor of the Johnsons at the President's House, 111 Memorial Drive.

Other tributes to Dr. Johnson by the Corporation included his election as Honorary Chairman, effective July 1, 1983, at the May 27 Meeting of the Corporation, the adoption of formal Resolutions on his retirement as Chairman, the inscription of a Paul Revere Bowl as a gift to him, and the presentation of a bound volume of personal letters from present and former Corporation Members, all at the same Meeting. Dr. and Mrs. Johnson were also honored at an MIT Community Reception on the Kresge Mall on June 9, and the following day, at the Technology Day Luncheon, Dr. Johnson was lauded by the Alumni Association. Outgoing Alumni Association President, Denman K. McNear, presented him with a Steuben glass beaver as a memento of that occasion. These and other expressions of appreciation and affection by the MIT family have marked a fitting conclusion to his 17 years as President or Chairman. I wish to express appreciation to Elizabeth J. Whittaker, Assistant Secretary of the Corporation, for her painstaking help in preparing many of the Corporation tributes to the retiring Chairman.

Departmental dedications during the year included the Centenary of Course VI and the new Charles P. Bowen Lecture Hall at 70 Memorial Drive as a teaching facility of the Alfred P. Sloan School of Management. In these activities this office served as an informal advisor to the department heads and deans.

CORPORATION DEVELOPMENT COMMITTEE

The report of the staff organization to support the resource development activities of the Institute is included elsewhere. At the same time no account of trusteeship can be complete without recognizing the participation of Members of the Corporation in the Council on Resources of the Institute, Corporation Development Committee, and Alumni Fund Board. In addition, many Members of the Corporation have headed or are serving as members of national sponsoring committees for professorship endowment projects or facilities.

Breene M. Kerr continued his role as Chairman of the MIT Sustaining Fellows. Several Corporation Members served as hosts at regional luncheons for the Sustaining Fellows. Eleven of the 37 members of the National Business Committee seeking major grants from US and foreign corporations were Members of the MIT Corporation: Louis W. Cabot, David R. Clare, Edward E. David, Jr., Angus N. MacDonald, Denman K. McNear, E. Kirkbride Miller, Carl M. Mueller, Ellmore C. Patterson, Richard L. Terrell, William J. Weisz, and Frank S. Wyle. Jerome B. Wiesner continued as Chairman of the Council for the Arts at MIT, Gregory Smith continued as Chairman of the Art Council's Development Committee, and the Arts and Media Technology Facilities Sponsoring Committee includes a number of Corporation Members. In Japan, Yaichi Ayukawa continued to serve as a central figure in organizing support by the Japanese government and Japanese companies. Stanley M. Proctor led a drive to secure endowment for the Class of 1943 Career Development Professorship. Our Corporation Development Committee member, Floyd A. Lyon, who was subsequently elected to the Corporation, received the 1982 Marshall B. Dalton Award of the Corporation Development Committee at its annual meeting "in recognition of conspicuous and sustained service in the enhancing of MIT's financial independence."

Altogether, these leadership responsibilities and actions by the Corporation represent a renewed sense of institutional purpose. They constitute a clear demonstration by the Institute's governing body of its commitment to secure the necessary resources for MIT's continued independence and strength in the years following the successful completion of the MIT Leadership Campaign. The Institute will always be grateful to the above-named and to the Corporation as a whole.

This year's achievement included an encouraging total of over $55 million in cash gifts, grants, and bequests receipts from the private sector. Despite the slow pace of recovery in the national economy, it was the Institute's best year on record in terms of private support.

MEETINGS

As a matter of record, the Corporation held four meetings during the year. At a time of continued financial stringency, Chairman Johnson, President Gray, and Provost Low called upon all segments of the Institute community to continue the budget limitations needed to pull together in planning for a future balanced budget. In addition, through its various committees, the Corporation played a key role in communication with students, faculty, alumni, and the general public on the range of questions and issues before MIT.

Special thanks are due to the Ad Hoc Committee on Shareholder Responsibility, under the chairmanship of D. Reid Weedon, Jr., for its continuing assistance to the Executive Committee of the Corporation, and to the Ad Hoc Committee on Information Transfer, under the chairmanship of Edward O. Vetter, for its excellent report to the Corporation on issues of secrecy in university research and education. Walter L. Milne, Assistant to the President and the Chairman of the Corporation, served again as Secretary to the Committee on Shareholder Responsibility and to the Ad Hoc Committee on Information Transfer.

Additional thanks are due the Corporation Screening Committee, under the chairmanship of David R. Wilson and the staff of the Alumni Association for the effort required to conduct the special alumni election needed to fill a vacancy in the category of younger Member of the Corporation.

In notable actions, the Corporation voted at its Annual Meeting on October 1, 1982 to change the designation of the Bachelor's Degree in the Department of Urban Studies and Planning from SB in Urban Studies to SB in Planning. At its December 3, 1982 Meeting, the Corporation approved the establishment of a new interdepartmental doctoral program leading to the PhD in Health Policy and Management to be offered by Whitaker College of Health Sciences, Technology, and Management in conjunction with the Departments of Political Science and Economics and the Alfred P. Sloan School of Management. At the same Meeting, the Corporation also voted to establish a new Master's Degree program in the Department of Political Science leading to the SM in Political Science and Public Policy.

At its May 27, 1983 Meeting, the Corporation voted to establish a new SM in Electronic Materials, to be recommended by the Department of Materials Science and Engineering. At the same Meeting, the Corporation approved the change in the designation of the Master's Degree in Polymer Science and Engineering from SM in Polymerics to SM in Polymers, to be recommended by the Department of Materials Science and Engineering.

At the May 27 Commencement Exercises, under the rain in Killian Court, Chairman Johnson welcomed past Chancellor Helmut Schmidt of the Federal Republic of Germany, the second outside invited speaker to address the graduating class in 20 years and the first German national to serve as Commencement Speaker since the founding of the Institute. The Corporation awarded its 100,000th degree to a degree recipient in the May 27 group of candidates. Each of the diplomas continues to be hand signed by the Secretary of the Corporation and presented to each degree recipient by the President each June, a tradition as old as the granting of degrees at MIT.

1983 marked the end of Chairman of the Faculty, Professor Felix M. H. Villars' participation in the regular meetings of the Corporation. The Corporation expresses appreciation to Professor Villars and to Provost Francis E. Low, both of whom contributed significantly to the discussions in Corporation Meetings during the year.

CORPORATION VISITING COMMITTEES

1982-83 was a year of uneven activity for the Corporation Visiting Committees. Eleven meetings were held in the first semester and only three meetings were scheduled in the second semester. Compared with 20 of the 28 Committees which met during 1981-82, a total of only 14 meetings were held in 1982-83. After experimenting with a speed-up in the frequency of Visiting Committee meetings for about 18 months, the Corporation, at its December 3, 1982 Meeting, decided to abandon the speed-up in favor of the normal cycle which has prevailed over the years. This change back to the normal cycle resulted in a transient effect -- the postponement of six or seven meetings until the fall of 1983.

The 14 meetings held in 1982-83 involved an average attendance of 14 Committee members each, or more than half of the total Visiting Committee membership, which now exceeds 570 members. The revised frequency of Visiting Committee activity will decrease Visiting Committee meetings from a 12 to 18 month cycle to an 18 to 24 month cycle. Thus, we plan to maintain a level of about 18 to 20 meetings a year, evenly divided as between the fall and spring semesters. The calendar for 1983-84 was started in this direction, with eight of the Visiting Committees so far scheduled to meet during the coming fall semester.

I want to recognize the extraordinary achievement of Ms. Mary S. Miller, Administrative Secretary in the Corporation Visiting Committee Office, in improving the scheduling and staffing of these meetings while earning a Bachelor's Degree at the University of Massachusetts at Boston during the past two years. Her associates congratulate her on this milestone. Ms. Miller has brought renewed strength and quality to the management of Visiting Committee activity.

Several features of the meetings which have proved successful in the past were continued by the Visiting Committees this year. All of the 14 meetings included dinner at which the Committee members were brought together informally with members of the faculty and administration. I wish to thank Jerilyn K. Edmondson, formerly of this office, for her volunteer assistance at several of these dinners. Also, the Committees made effective use of private sessions with students on their agenda, further formalizing this additional and valuable means of gaining insight into departmental activities. A number of the Committees for larger departments included similar separate sessions with younger, untenured faculty. Discussions with each of the departments had many common interests, including systematic follow-up of previous Committee recommendations and reviews of departmental progress in recruitment of minorities and women as students and faculty members.

During 1982-83 we completed a two-year effort initiated by President Gray to increase the number of highly qualified women and minorities serving on the Corporation Visiting Committees. By permitting the average size of the Visiting Committees to grow from 18 to 21 members, a substantial increase in both women and minorities has been achieved, with a foundation for future growth. An approximate doubling has taken place in both categories. Women now represent 20 percent and American minorities now represent 10 percent of the total number of 575 positions in the Visiting Committees. These percentages far exceed the national participation of women and minorities in advanced fields of science and engineering, and they exceed the participation of women and minorities in the MIT faculty. They approximately equal the current percentage of women and minorities earning MIT degrees. I wish to acknowledge the continuing assistance given this worthwhile project by several Members of the Corporation, the deans and department heads, the Nominating Committee for Visiting Committees of the Alumni Association, under the chairmanship of our new Corporation Member, Joseph G. Gavin, Jr., a number of internal groups at MIT, and most importantly, President Gray.

The participation in this year's series of meetings by the senior officers and deans of the Institute continued at a high level. The presence of these officers at the various meetings enhances the interchange between the committee and the department and often provides a welcome catalytic effect which contributes to the success of the meeting. Enduring thanks are due Provost Francis E. Low for his diligent participation in all of the meetings, and to the more than 300 faculty members who participated in the sessions of the Visiting Committees.

Of the Committees meeting in the 1981-82 year, all of the chairmen have now reported orally to the Corporation, and all save two have submitted written reports. These reports to the Corporation are important to the successful operation of the Committees, and they provide a broadened forum in which to consider the plans and progress of each department. They are invaluable to the functioning of trusteeship at MIT. The Academic Council systematically receives copies of the written reports when they are approved for distribution by the Executive Committee, and the Council also hears oral reports from the Provost and the responsible dean or vice president as Visiting Committee meetings occur.

The introduction of office automation has provided a permanent alternative to adding a third support staff member. The budgetary savings in reduced overtime payments alone will substantially offset the cost of two DECmate word processors over a period of two to three years. More importantly, for the first time in 20 years the need for a third support staff member has been eliminated and the support staff workload has become more manageable. Enduring thanks are due Iris E. Lazarus, Administrative Secretary, who took the lead in installing our DECmate word processors and who helped to train others in nearby offices on the use of their new machines.

An interesting development is continuing in the growth of "advisory boards" and committees affiliated with some of the major research laboratories and centers of the Institute. These advisory boards are not formally a part of the Corporation Visiting Committee system. They have been organized by the offices of the Vice President for Research and the Dean of the School of Engineering to serve the need of specific centers for an advisory body reporting to the Dean or the Vice President and providing advice to the research program director. At the same time, a number of Corporation Members chair or serve on these advisory boards, and have found them worthwhile and useful for the purposes intended. External advisory boards or committees have now been established for some 10 centers or laboratories. It is hoped that an annual compilation of these boards can be made in the future to give greater recognition to the nearly 200 people serving as members and to encourage the increased appointment of women and minorities to these boards.

The Office of the Secretary of the Institute has encouraged the directors of laboratories who have sought advice in establishing the various advisory boards. There is still some residual confusion between the functions of the advisory boards and the Corporation Visiting Committees, but I believe some progress has been made in distinguishing between the two. This aspect continues to be studied. The Membership Committee of the Corporation has tried to take account of Corporation Member participation in these advisory boards in planning Visiting Committee assignments in recent years.

I wish to thank Dorothy G. Adler of the MIT Alumni Association for her strong support of the nomination of alumni to the Visiting Committees and for her assistance to the Corporation Screening Committee for younger alumni. I am irretrievably indebted to Iris E. Lazarus for her heroic performance in handling the quarterly meetings of the Corporation and related affairs. She stands alone among others with whom I have worked in her ability to absorb sheer workload cheerfully and efficiently.

Priscilla K. Gray once again heads the list of MIT volunteers for the quality and character of her manifold contributions. Major programs and constituencies of MIT, at home and abroad, all owe her a growing debt for the warmhearted manner in which she has welcomed and encouraged every program and person at the Institute. It is a pleasure to see her work her magic on MIT, and it requires some discipline to realize that each day represents a fresh new gift on her part to this institution.

The year has been punctuated with so many truly outstanding events and accomplishments that it is difficult to single out any one of them. For the writer, the naming of Ida Flansburgh Green Hall has particular meaning. President Gray and Chairman Johnson said on that occasion "MIT is proud to associate Ida Flansburgh Green's name with its first residence hall for women graduate students. Ida Flansburgh Green Hall honors a woman who has long been concerned with both the strength and vitality of MIT and the encouragement and expansion of opportunities for women students here." Ida Green has earned the permanent respect and admiration of MIT men and women the world over. She and Cecil Green have touched the lives of countless human beings around the globe. Her name is fittingly joined with the distinguished roster of names on MIT residences overlooking the Charles River. I congratulate her on this latest recognition.

This report closes on a hopeful note. The opportunity to work closely with the Chairman and the President in the governance of MIT is a privilege not accorded to many officers of the Institute. I feel that responsibility deeply. The new combination of Chairman Saxon and President Gray will be the fifth sequence of Chairman-President pairings under whom I have served directly during the past 20 years. The pairings have changed every five years on the average. The spirit of renewal which has accompanied each of these new pairings has brought home time and time again MIT's remarkable ability to move gracefully from one period to the next under new leaders, seemingly without missing a beat in its corporate life. It is a measure of MIT's basic quality and coherence that changeover becomes an opportunity for reexamination of everyday routines and rededication to the Institute's basic mission. I am sure that the happy addiction which Vannevar Bush so aptly called the Institute's habit of success has its roots in this inherent capacity for self-renewal.

VINCENT A. FULMER

Alumni Association

The goal of the MIT Alumni Association is "...to serve the purposes of the Institute and to further its well-being by fostering the interest of alumni in the Institute and in each other...." To do so requires the dedication of many active volunteers, over 5,000 in 1982 and 1983, the hard work of a small staff and the collaboration and support of our 77,000 living alumni. This year the Institute was again exceptionally well served by each of these bodies resulting in another extraordinary year of accomplishment.

For the second time, the first in 15 years, the Alumni Officers Conference, the annual meeting for alumni volunteers was taken "on the road" to San Francisco and Philadelphia to reach alumni and alumnae previously unable to come to Cambridge.

Significant progress was made in strengthening the Association's ties to graduate students through collaborative efforts with the Graduate Student Council.

As always, our greatest achievements came as a result of the work of active, committed volunteers. Some include the successful transplant of the "Boston Seminar Series" to Washington, D.C. and San Francisco; the continued successful growth and export to other cities of The Enterprise Forum, a series of workshops and case presentations to help entrepreneurs using alumni entrepreneurial expertise; the very successful sponsorship of "Black Students Conference on Science and Technology" by The Black Alumni of MIT (BAMIT).

In fund raising the Alumni Fund reached another record, $8.7 million, and achieved new highs in members and percentage of donors above $100 and a new record level of contributors exceeding the previous record by almost 1,000 contributors. This success resulted from the active participation of over 1,000 alumni and student volunteers, ably led by James K. Littwitz, Class of 1942, Chairman of the Alumni Fund Board, supporting the Fund and Association staff led by Joseph S. Collins, Director of the Alumni Fund. Notable this year was the continued growth in the percentage of donors participating as members of the Great Dome Associates with gifts of $250 or greater.

Each year the Association is led by a distinguished alumnus or alumna. During 1982-83 Denman K. McNear, Class of 1948, Chairman and Chief Executive Officer of the Southern Pacific Transportation Company served with distinction in this role. McNear was the first President of the Alumni Association from the West Coast and brought to his role a fresh and different perspective of alumni activities. He and his fellow Directors held two unprecedented Board meetings away from Cambridge to make the Board more visible to alumni in distant cities.

During the year four new members were added to the staff, three resigned, and one long-time employee suffered a long-term disability requiring her retirement. Of those hired, Neil Didriksen assumed the position of Associate Director of the Alumni Fund; Rajeshwari Patel, Class of 1977, became Regional Director for New England; Janet Serman Lambert became Director for Course Programs reporting to the Alumni Fund but with responsibility to both the Director of the Fund and the Secretary of the Association; and Carol Roberts joined the staff as Information Retrieval Manager.

A new alumni organization was formed in Singapore and the Alumni Association was granted official status in the People's Republic of China. Joint efforts were begun with the Industrial Liaison Program in the production of videotaped technical presentations. Successful joint departmental efforts continued with a notable high point being the celebration of the Centennial of the Electrical Engineering and Computer Science Department which attracted a wide alumni audience to the campus and provoked a significant in-depth look at lifelong learning.

None of the above or the too numerous Club, Class, Departmental or other alumni activities could have succeeded without the willing and energetic support given to the staff by the 5,000+ active alumni.

Alumni Relations

The annual Alumni Officers Conference was held this year in two off-campus locations--San Francisco on September 24 and 25, 1982 and Philadelphia on October 8 and 9, 1982. The goal of both was to help alumni in their roles as fund-raisers, educational advisors, and leaders of classes and clubs; and the idea of two regional meetings was to bring this help to alumni who could not travel to Cambridge for the usual annual conference. It worked: of more than 300 attending the two meetings, at least two-thirds had never attended a Cambridge-based Alumni Officers Conference. Workshops were held on regional activities, class reunions, course/departmental programs, the Alumni Fund, and the Educational Council. The Alumni

Association business meeting was followed by an awards luncheon in each location, then afternoon symposia. In San Francisco, four faculty members from the Department of Electrical Engineering and Computer Science discussed MIT's role in VLSI (very large scale integrated circuit) design. In Philadelphia, Dr. Francis E. Low and three faculty members from the Energy Laboratory and the Department of Nutrition and Food Science discussed MIT's role in energy for the year 2000. These symposia were followed by a banquet at which President Paul E. Gray, Class of 1954, was the keynote speaker, reporting on Cambridge affairs that conference participants could not observe first-hand, as well as the Institute's financial situation. Because of the success of this year's experiment, we will continue the concept of alternate year off-campus AOC's. A decision was also made this year to rename the AOC the National Alumni Conference, to reflect broader volunteer involvement.

The Alumni Council series this year was an outstanding success, with large audiences (average attendance 138). Featured speakers included Professor Ernest G. Cravalho, Dean Gerald L. Wilson, Class of 1961, Dr. Louis Menand, Professor Lester C. Thurow, Professor Peter H. Smith, and Dr. Gray.

Student/alumni programs continued to be an area of strong commitment for the Association. The Alumni Host Family Program matched up seventy incoming freshmen and transfer students with alumni residing in the Boston area, for social as well as career mentorship purposes. The Senior Dinner program was held again this year, with Dr. and Mrs. Gray (Honorary) hosting ten dinners at the President's House during the months of February and March, 1983. Each dinner featured a brief presentation about the Association's organization and activities; alumni described their professional careers and history of service on behalf of MIT; and students described their plans for the future. 547 students attended these dinners--43% of the senior class. The Alumni Association assisted student groups looking for speakers. Several career-oriented discussions featuring alumni were sponsored by the Association during the year. International alumni continue to perform a very important role, offering support and advice to newly admitted students. Many MIT clubs invite admitted freshmen and their parents to club events held in the spring, and continue to invite all students from their respective areas to holiday and summer events. A number of MIT clubs continue to sponsor summer job programs for students from their respective areas.

The Black Alumni of MIT (BAMIT) sponsored the 10th Annual "MIT Black Students' Conference on Science and Technology" on October 15 and 16, 1982. This was the first year BAMIT took over total responsibility for this conference from the Dean for Student Affairs Office, and attendance was 350. BAMIT also sponsored their annual welcoming reception for incoming minority students on September 24, 1982 and their exit reception for graduating minority students on May 22, 1983.

The Association of MIT Alumnae (AMITA), in conjunction with the Boston Section of the Society of Women Engineers, sponsored their third annual conference, "Sophisticated Ladies: Corporate Knowhow for Technical Women," on April 9, 1983, at MIT. Attendance was approximately 300, double the attendance of the previous year's conference. AMITA sponsored for the seventh successive Independent Activities Period the workshop, "Getting the Job You Want in Industry: A Woman's Guide to the Pinstriped World," a recurring event which draws from 30 to 50 participants each year. AMITA also continued its High School Visiting Program, where 80 alumnae volunteers visited 30 high schools to talk to groups of women students about how important it is to continue to study mathematics and science so they can preserve a wide variety of career options. More than 2,000 high school students were reached with this very important message.

We have started, cooperatively with an Admissions Office initiative, to recognize the possibility of forming a Chicano alumni group. If responses to that office's survey are strong, the Association will pursue this in the coming year.

The MIT Enterprise Forum has expanded both locally and nationally this year, and its list of subscribers has increased to approximately 2,000 people. The Boston-area Forum's annual workshop, this year held on October 30, 1982 and entitled, "The Business Plan--Blueprint for Success," drew an audience of 350. Their IAP seminar on "Management of the High Technology Company: The Engineer as Entrepreneur," drew 30 attendees at each of four sessions. The newly established program for "start-up" ventures drew 18 companies to meet with bankers, venture capitalists and other professional counselors. Other active Enterprise Forums exist in New York, Washington DC/Baltimore, Chicago, San Francisco, and Los Angeles, and new programs are in various stages of formation in several other cities. The group in Washington DC/Baltimore became particularly active this past year, and sponsored a highly successful workshop, "Technology-Based Business: Strategies, Techniques, and the Business Plan" on April 30, 1983, with an attendance of 150.

The Boston Seminar Series this past year consisted of six meetings on the topic "Global Interdependence vs Competition: The Diminishing Role of U.S. Self-Sufficiency," with an audience of approximately 165 at each meeting. For the first time, this concept was successfully "exported" to the Washington DC area, where a series of six meetings addressed the issue of "Science and Technology: Has the U.S. Lost the Initiative?" The audience size was 80, a remarkable achievement for this series' first year. San Francisco had two series: fall, three sessions on "The Nuclear Weapons Dilemma," attended by 75 subscribers; and spring, two sessions on "The Japanese Phenomenon: An Industrial Giant," attended by 55 subscribers.

The Cardinal and Gray Society, established formally in 1980 for alumni residing in the mid-New England region who have celebrated at least their fiftieth class reunion, held two very well-attended meetings this year at Endicott House. Mr. Howard W. Johnson (Honorary) spoke to the largest crowd ever on October 17, 1982 and Professor Lincoln Bloomfield spoke on May 1, 1983.

Technology Day on June 10, 1983, focused on the topic "How Can We Live With (Without) Artificial Intelligence?". Attendance at the symposium was 1,200 with a turnout of 2,100 at the pre-Technology Day festivity, "Tech Night at the Pops," held on June 9th at Symphony Hall. Thirteen reunions, held between the dates of June 8 and 12, 1983, brought back to campus a total of 1,300 alumni and guests.

In the regional area, the five Regional Directors, the President of the Alumni Association, as well as senior Association and Institute staff, travelled extensively on behalf of the Institute. Some regional events are especially worthy of note. On September 30, 1982, the first "Medical Lecture Series" began in New York City, featuring Dr. Salvador Luria and reached a previously unaddressed audience of 75. That city also pioneered "The MIT Exchange," a new series which will probe issues related to technology and society, with two high successful meetings--"Technology and Education in a Changing World" featuring Dean Gerald L. Wilson on October 14, 1982, and "Revitalizing American Productivity Through Alternative R&D Policies" featuring William Norris, Chairman of Control Data Corporation, on April 28, 1983. The MIT Symphony played to an audience of 1,200 (400 alumni) at Carnegie Hall on April 24, 1983. The Mexican Fiesta took place in Mexico City and Oaxaca March 4-9, 1983 with 110 attendees. The Florida Festival took place at EPCOT in Orlando on March 11-12, 1983, attracting a broad range of 130 alumni of the classes of 1921 through 1982. On November 9, 1982 the Club of Southern California sponsored an event at the Getty Museum which attracted a group of 460 and is noteworthy because it was our first attempt to involve parents of MIT students in club events in their region. On March 16, 1983, the Club of Northern California initiated a new series on "Distinguished Alumni," featuring George Keller, Class of 1948. The Club of Southern California featured Dr. David Saxon, Class of 1941, as its speaker at its annual meeting on June 14, 1983. Organizing efforts were focused this past year in Albany/Schenectady, Detroit, Houston, Long Island, New Orleans, and Providence. We are especially grateful to Alumni Association President Denman K. McNear, Class of 1948, and President-Select Robert W. Mann, Class of 1950, for their presence at several important events.

The Committee on Alumni Nominations for Corporation Visiting Committees recommended to the Corporation that 26 members whose terms had expired be ended, that 31 terms be extended, and that 33 new alumni members be appointed to Visiting Committees.

The Board of Directors appointed 31 new alumni members and seven chairmen to serve on the seven national boards and committees of the Association. The Board also approved the following recommendations of the Awards Committee:

Bronze Beaver Awards: Ernest U. Buckman, Class of 1946; Robert C. Cowen, Class of 1949; Russell N. Cox, Class of 1949; Wayne J. Holman, Jr., Class of 1939; George M. Keller, Class of 1948; and Horace W. McCurdy, Class of 1922.

The Harold E. Lobdell, Class of 1917, Distinguished Service Awards: Kenneth Armstead, Class of 1975; C. William Carson, Class of 1952; James Cunningham, Class of 1957 (posthumously); Philip H. Dreissigacker, Class of 1937; Sumner Hayward, Class of 1921; William Hosley, Class of 1948; Christina Huk Jansen, Class of 1963; Carol C. Martin, Class of 1977; Lita Donnelly Nelson, Class of 1964; Hector Orozco, Class of 1945; and Viguen Ter-Minassian, Class of 1964.

The George B. Morgan, Class of 1920, Awards: Charles Bossi, Class of 1942; Dexter Clough II, Class of 1935; George Heller, Class of 1959; Guillermo Machado-Mendoza, Class of 1946; Marshall McCuen, Class of 1940; and Arnold Singer, Class of 1948.

Presidential Citations: BAMIT, for its role in the MIT Black Students' Conference on Science and Technology; Cardinal and Gray Society; Class of '77 5th Reunion Gift Committee; Department of Electrical Engineering and Computer Science Centennial Celebration; Sloan Alumni/ae Activities; and Technology/ Rochester Symposium, March 13, 1982.

Honorary Membership in the Alumni Association: D. Hugh Darden, Julia C. McLellan, and Salvatore Lauricella.

The following alumni were elected by national ballot to serve three-year terms on the National Selection Committee: Philip H. Dreissigacker, Class of 1937, District Three; Robert L. Rorschach, Class of 1943, District Eight; and Paul P. Shepherd, Class of 1953, District Nine.

The Association supports the Corporation Screening Committee ballot process through which degree recipients 1981/1982/1983 elected Rhonda Peck, Class of 1982, to serve a five-year term on the Corporation.

The National Selection Committee made the following selections for terms starting July 1, 1983:

Terms on the Corporation: Denman K. McNear, Class of 1948; Joseph G. Gavin, Jr., Class of 1941; and Floyd A. Lyon, Class of 1942 (all five year terms).
President of the Association: Robert W. Mann, Class of 1950 (one year term).
Vice Presidents of the Association: E. Milton Bevington, Class of 1949 (two-year term); Richard A. Jacobs, Class of 1956 (one-year term) and C. Vincent Vappi, Class of 1949 (two-year term).
Directors of the Association: Jerome T. Coe, Class of 1942; Michael H. Kaericher, Class of 1962; David E. Gushee, Class of 1950; Raymond H. Danon, Class of 1958; and Roger S. Borovoy, Class of 1956, (all two-year terms).

Frances H. Bangs, Manager for Class Programs, and Carol D. Seligson, Class of 1971, Regional Director for the Gulf/Atlantic Region, left the Association to pursue other professional interests. Paul E. Johnson, Regional Director for New England, took over responsibility for the Gulf/Atlantic Region. Rajeshwari R. Patel, Class of 1977, joined us as Regional Director for New England. Lawrence E. Milan, Regional Director for the Midwest, had his region expanded to include Washington, DC and Maryland. Dorothy G. Adler was promoted to the position of Coordinator for Alumni Selection and Recognition Processes, and Janet Serman Lambert was promoted to Director for Course Programs.

Alumni Fund

Under the chairmanship of James K. Littwitz, Class of 1942, the Alumni Fund set new records for support of the Institute by its alumni. A total of $8,662,468 was received in contributions from 26,811 alumni, resulting in participation of 43 percent. These results mark the fifth consecutive year in which the dollars received and the number of contributors to the Alumni Fund exceeded the prior year's totals. Further, in addition to achieving a new million dollar giving level--marking the fourth time in the past five years--the $8.7 million represents the ninth straight year of increased dollars in the Alumni Fund. Other significant achievements include the 7,300 contributions (27 percent) of $100 or more to the Fund, the $1.2 million received in corporate matching gifts, and 1,953 first-time gifts to the Fund. In addition, participation by undergraduate alumni reached 50 percent for the first time. These results were made possible by the efforts of some 2,000 alumni and student volunteers who made solicitation visits and calls on behalf of the Alumni Fund.

Continuing the pattern of recent years, most Fund programs (including Direct Mail, Major Reunion Gift, Matching Gift, Personal Solicitation (P.S.), Senior Gift and Young Alumni) were conducted in the established format. In an effort to increase support from alumni with an MIT graduate degree exclusively (GSE), a new staff position, Director of Course Programs, was established with responsibility for both Alumni Fund and Relations activities. A key element of the position is working with the heads of MIT's academic departments.

Telethons continue as the primary method of reaching a significant portion of the alumni population to seek increased levels of support for MIT. Both on campus and in 23 cities across the United States, volunteer callers achieved record totals. These 1,248 alumni and students contacted more than 17,000 alumni (28 percent of the alumni population) and received nearly $600,000 in pledges from some 12,000 individuals. All of the totals exceeded the results of prior years. Moreover, a special effort was made to recruit GSE alumni as callers in order to increase support from graduate alumni.

In addition to participation in Telethons, alumni from eight regions served as solicitors in last fall's P.S. program. Conducted in major metropolitan areas, some 100 specially trained alumni contacted in a personal way more than 350 prospects, seeking upgraded gifts to MIT. Of the nearly 300 alumni who pledged, 54 percent increased their level of support for MIT, meeting the objectives of this key solicitation program.

The continued support of MIT by its young alumni is particularly satisfying. A total of 758 alumni from the five most recently graduated classes made first-time gifts to the Fund. In addition, the Class of 1978, continuing the precedent established one year ago, presented a gift of $18,000 in honor of its fifth reunion. Also, 72 percent of the class has made at least one gift to the Alumni Fund since graduation. This remarkable figure was achieved in one half the time that has been typical of recent young classes. Providing further evidence of young alumni support,the Class of 1983 established a new record by having 346 members of the class participate in its Senior Gift to MIT. A total of $4,350 was presented, supplemented by $6,700 in matching funds by the 50th Reunion Class of 1933. Additional pledges of $18,900 were made by 289 members of the class. Total participation in this effort was 39 percent. All figures represent new records.

Major reunion gifts totalling more than $13.8 million were announced on Technology Day 1983. Included in this amount were gifts received in the prior years and pledges payable through 1988. The 50th Reunion Class of 1933 announced a total gift of $3,651,000, the second largest in the history of MIT, with 55 percent of the class participating in the effort. Moreover, plans for future gifts from members of the class total $2.6 million. The Class of 1943, celebrating its 40th Reunion, announced a gift of $2,288,000. Included in this total was $547,000 to endow a Class of 1943 career development professorship.

57 percent of the Class participated in the 40th Reunion Gift, which is the largest 40th Reunion Gift from living alumni to MIT. The Class of 1958 presented a 25th Reunion Gift of $702,000, which includes $313,000 to endow an assistant professorship. 57 percent of the Class of 1958 participated in the reunion effort. Additionally, the Class of 1923 presented MIT with $7.2 million in celebration of its 60th Reunion, the first 60th Reunion Gift in Institute history. During the year, there were 16 luncheons held in major U.S. cities for alumni approaching their 40th and 50th reunions. These meetings inform alumni of the many means that can be used to make a substantial gift to MIT, including life income plans.

Alumni giving at the $250 or greater level has increased by 92 percent since the inception of the Great Dome Associates in 1981. This year 10 percent of the total contributors to the Fund are in this category.

Finally, the Alumni Fund underwent a significant change in staff this year. Nancy L. Russell, whose energy and ability contributed so very much to the recent success of the Alumni Fund, resigned as Associate Director to relocate in Pittsburgh, PA. Roberta A. Carrara, Rhonda E. Peck, Class of 1982, and Jeffrey R. Solof, Class of 1981, also left the staff. The Alumni Fund is pleased to welcome Neil W. Didriksen and Janet S. Lambert to the staff and thank them for their efforts in achieving this year's outstanding results.

Technology Review

1982-83 was a year of mixed signals for Technology Review. Our sense is that the magazine was a better editorial product--timely, well-written and edited, distinguished by its design and illustration--than ever before. But our signals from the marketplace were mixed: the total number of our paid (non-alumni) subscribers grew, but our costs to acquire and retain those subscribers were intolerably high. Meanwhile, advertising and miscellaneous income exceeded that of any prior year.

At the risk of demeaning (by omission) many valuable contributions to 1982-83 issues of the Review, it's possible to list a few editorial highlights: "When Cracks Become Breakthroughs," a literate and complete account of the problems of structural fatigue failures, by Professor Henry Petroski of Duke University; an account of the rapid technological change and its consequences for the U.S. auto industry by Martin Anderson, executive officer of the MIT program on the Future of the Automobile; "What to Do About Acid Rain," by Professor Eville Gorham of the University of Minnesota; Lord Solly Zuckerman on Europe's view of nuclear military technology; a report on how the White House was ill served by computer technology by Professor Amitai Etzioni of George Washington University; "Measuring the Intangible in Productivity," an essay on how to think about the productivity of service and research enterprises, by Michael B. Packer of the Laboratory for Manufacturing and Productivity at MIT; some observations on the Brooklyn Bridge in particular and U.S. bridge maintenance problems in general by Blair Birdsall of the New York firm of Steinman, Boynton, Gronquist, and Birdsall; a student view of the "2.70 design contest" by Pepper White, an MIT graduate student; and a pair of reports on wave and tidal power by Professors J.N. Newman, Class of 1956, and James A. Fay, SM, Class of 1947, respectively, of MIT.

Mr. White's article was cited for "exceptional achievement" in the "Best Articles of the Year" competition conducted by the Council for the Advancement and Support of Education, and the Review was ranked high among the 10 best college magazines of the year by CASE. Several articles and illustrations in Technology Review were included in the 1983 Design Show of the Art Directors Club of Boston.

Though no formal reader survey work was done in 1982-83, readers' informal responses--especially those from alumni, from whom we hear most frequently--to the Review were very positive. The flow of letters from readers assures us that we have a loyal and interested audience.

Meanwhile, the signals from the marketplace were less than wholly reassuring, being a repeat of our experience of 1981-82: a thoroughly adequate response from new subscribers to our invitations for "free" issues and/or "trial" subscriptions but an inadequate rate of payment by these would-be readers at the end of their "free" or "trial" subscription periods. Thus, for the second straight year our subscription income fell significantly short of budget. Meanwhile, alumni and student subscriptions increased--alumni because of their increasing participation in the Alumni Fund, students by the inclusion of many graduate students as well as undergraduate upperclassmen for complimentary copies of the "student" edition. Both these factors served to further increase the cost of Technology Review, since compensating income was not available.

Other revenue sources--advertising, newsstand sales, reprints and back issues, and mailing list rentals--were in excess of budget, with advertising pages and income reaching a new record high.

To help us deal with the inadequate marketplace response from new subscribers to Technology Review, we have retained counsel during the year from Robert Cohen of Robert Cohen Associates, who has had considerable experience in magazine management including in the field of technology. Though it's clear that much of our difficulty arises in the increasingly competitive situation of Technology Review, with a number of new magazines now in the science/technology marketplace, Mr. Cohen is confident that the Review's competitive position can be improved. He is working with us to develop new sales materials and to help the editors focus the magazine on its special "niche" served by no other similar magazine: the evaluation

of new technologies in terms of their present and future implications for human affairs.

The Review suffered a serious setback in March with the departure of Steven C. Marcus, Managing Editor since 1979, to join the Financial Department of The New York Times. Dr. Marcus had a very strong sense of Technology Review's mission and boundless talent and energy in support of the magazine, and our efforts to fill his empty desk have served so far only to reveal how strong were his contributions.

Alison Bass joined Technology Review at the beginning of 1983, replacing Ellen Shell who resigned her post as Senior Editor to take a similar assignment at Technology Illustrated. Ms. Bass served for several years as science reporter for the Harvard News Office and most recently had been a reporter covering political and science stories for the Miami Herald.

The Review's Advisory Board, chaired by Claude W. Brenner, Class of 1947, met early in the spring, and the Review received intensive discussion at several meetings of the Board of Directors of the Alumni Association. The suggestions of the Advisory Board and of the Board of Directors have been most helpful, and the confidence of the Advisory Board in the concept of the magazine and its stewardship by the staff has been invaluable. These remarks apply equally to the incumbent members of the Advisory Board and the new members who joined prior to the 1983 meeting: O. Reid Ashe, Class of 1970, Executive Editor of the Jackson (Tennessee) Sun; Dr. William Bennett, President of Harvard Magazine; Fred Jerome, Director of the Media Resource Service of the Scientists Institute for Public Information; Victor K. McElheny, Curator of the Bush Fellowships, MIT; Professor Emma Rothschild of the Program in Science, Technology, and Society, MIT; and Victor Weisskopf, Institute Professor Emeritus (Physics), MIT.

Records/Administration

The activities of day-to-day production and data entry on the new data base management system became familiar and routine during this past year, while tasks of debugging the installed system, programming additional reports, and documenting the installed system continued. Preliminary development was undertaken for a file of activities by alumni on behalf of MIT and the Alumni Association, and for a file of the histories of gifts to MIT. Documentation of the Master File was undertaken with written definitions of the data elements. In this process, decisions were made about retention of elements carried over from the old system, laying the groundwork for a task list for cleaning up residual problems in the Master File.

In addition, a file was added to the data base by Resource Development to be used in controlling their prospecting operations, and planning was initiated towards eventual integration of the Sloan School computer files on their graduate alumni into the Alumni/Gifts data base.

During this year work was begun towards producing a new MIT Alumni Register. The end results of this project will include conversion of names and addresses in the data base from all uppercase to combined upper and lower case, improved data integrity and the addition of new data.

The move of the computer center from Building 39 to W91 imposed some disruption of operations and requirements for testing before and after, but the impact was relatively mild. Issues of ongoing concern include production support of the system, the need for a new costing and billing system for IPS/AIS to provide us with badly needed managerial information, and the reduction of development support as a result of the assignment of new application development tasks for other clients to the IPS/AIS area team.

In September 1982 the position of Information Retrieval and Production Manager was filled by Carol E. Roberts.

WILLIAM J. HECHT